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UNITED STATES GEOLOGICAL SURVEY
J. W. POWELL, DIRECTOR

FOSSIL FISHES AND FOSSIL PLANTS

OF THE

TRIASSIC ROCKS

OF

NEW-JERSEY AND THE CONNECTICUT VALLEY

BY

JOHN S. NEWBERRY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1888

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LETTER OF TRANSMITTAL.

COLUMBIA COLLEGE, NEW YORK,
August 1, 1887.

SIR: I have the honor to transmit herewith a memoir prepared at your request on the Fossil Fishes and Fossil Plants of the Triassic Rocks of New Jersey and the Connecticut Valley.

With great respect, your obedient servant,

J. S. NEWBERRY.

Hon. J. W. POWELL,
Director U. S. Geological Survey.

PREFACE.

It is hoped by the author that the following pages will do something to supply what has long been felt to be a want in American geology: a better knowledge of the fauna and flora of the Triassic rocks of eastern North America. These rocks probably furnished the first fossils collected on this continent—fossil fishes from Durham and Sunderland, in the Connecticut Valley; fossil plants from the coal basin of Richmond, Va.; and, still more interesting, the wonderful series of so-called bird tracks first noticed at Turner's Falls, Mass.

A few of the fossil plants of Virginia were described by Prof. W. B. Rogers in the reports of the Association of American Geologists and Naturalists, 1843, and by Mr. C. J. F. Bunbury in the Quarterly Journal of the Geological Society of London, volume 3, 1851, and some notices of the fossil fishes, with brief descriptions of certain species, were published by Agassiz, Sir Philip Egerton, and Messrs. W. C. and J. H. Redfield, at various times between 1838 and 1856. Many figures and descriptions of the remains of both plants and animals were also published by Prof. Ebenezer Emmons in his Geological Report of the Midland Counties of North Carolina, in 1856, but, though deservedly eminent as a geologist, Professor Emmons had little acquaintance with paleontology, and this contribution rather increased than satisfied the desire for more thorough knowledge of the life of the Atlantic coast in Mesozoic times. No systematic collection nor thorough study of the fauna or flora of the formation as a whole was attempted until about 1880, when Prof. W. M. Fontaine, of the University of Virginia, began a careful review of the fossil plants of the Virginia and North Carolina

Mesozoic coal basins. His results were published in a memoir on The Older Mesozoic Flora of Virginia, which was issued in 1883, as volume 4 of the Monographs of the U. S. Geological Survey. This threw a flood of light upon the vegetation of the Atlantic coast in the Mesozoic ages and established beyond question the parallelism of our New Red Sandstone with the Keuper of Europe; a matter which had been much debated, with somewhat discordant conclusions, by Hitchcock, the brothers Rogers, Lyell, Marcou, and Emmons.

Thus one of the wants which has been referred to was satisfactorily supplied; but the animal remains found in our Triassic rocks are still to be systematically reviewed. The immense series of tracks of terrestrial animals found on the old beaches of the Triassic estuaries—the autographs, as I have elsewhere called them, of at least one hundred different kinds of bipeds and quadrupeds of diverse sizes and structures which inhabited the eastern coast of North America in the Triassic age, and left little other record of their existence—though beautifully illustrated by Hitchcock and Deane, are still as mysterious and tantalizing as ever. Comparatively few bones of the animals themselves have been met with up to the present time; but these confirm the conclusions, drawn from the remains of terrestrial Mesozoic animals found elsewhere, that the tracks referred to were not made by birds as first supposed, but by reptiles or amphibians. Doubtless in future years some Mesozoic cemetery will be discovered like those of Tilgate Forest in England and Bernissart in Belgium, where the abundance of vertebrate remains and the perfection of their preservation will permit the rehabilitation of this interesting fauna.

The fossil fishes of our Triassic rocks have long needed a fuller exposition than had thitherto been given to them. The materials upon which the Messrs. Redfield based their important contributions to our knowledge of this group of fossils were incidentally collected from surface exposures and were necessarily limited in quantity, the fossils themselves were generally fragmentary and imperfect, and an interval of more than thirty years has elapsed since their last communication was made on this subject. Having long been interested in the Paleozoic fishes of Ohio, when I came to New York to reside and began to form a geological museum at Columbia

College my attention was naturally directed to these, the most striking fossils to be found in the vicinity. After obtaining by purchase good specimens of all the species to be had in the valley of the Connecticut, men were employed to make excavations in the fish beds at Boonton, N. J., and from that locality many hundreds were obtained in a good state of preservation. These, with those procured elsewhere, gave me much more and better material for study than had been accessible to any one else who had been interested in the subject. The accumulation of this new material made it apparent that our Triassic rocks contained some genera not before found there and a larger number of species than had before been described. In order to identify these I examined the collections made by the Messrs. Redfield, all of which were courteously placed at my service by Prof. O. C. Marsh, as were those in the American Museum of Natural History by Prof. R. P. Whitfield and those in the cabinet at Amherst College by Prof. B. K. Emerson. My first intention was simply to identify the species which had come into my possession, but I soon found that to do this satisfactorily all the literature of the subject and all accessible material, both old and new, must be passed in review. When this had been done it seemed to me that the facts I had gathered would be a valuable contribution to American geology if they could be put into shape and published, and the following memoir is the result of an effort in that direction.

Many circumstances have rendered my task a difficult one. I have endeavored with sincere loyalty to my old friends W. C. and J. H. Redfield, father and son, to secure to them as far as possible the fruit of their study of our Triassic fishes; but, from the limited amount and the imperfect preservation of the material in their hands and the brevity of their descriptions it has not always been possible to identify and accurately define their species. Besides this, many of the specimens which served as their types were burned with the other collections of the New York Lyceum of Natural History, and of the specimens remaining in the Redfield collection the greater part are without other labels than numbers to which no corresponding catalogue has been discovered. For these reasons I feel that in regard to specific distinctions my work is imperfect and is liable to modification with the gradual accumulation of more and better material. I have

thought, however, that the fossil fishes from our Triassic rocks which have been lying in the cabinets of our colleges and collectors should if possible be made available for the use of teachers and students, and should contribute their part to illustrate what is perhaps the most interesting and yet least known epoch in the geologic history of North America, that of the Trias. As a contribution to this history I have accumulated by far the largest collection of our Triassic fishes yet made, have studied them with some care, have labeled them plainly according to my lights, and have placed them in the Geological Museum of Columbia College, where they will be safe, since it is fire-proof, and where they will be accessible to those who shall carry to completeness the investigations of these fossils begun by the Messrs. Redfield, continued by me, and to be concluded by generations yet to come.

In conclusion I desire to express my obligations for assistance and courtesies received from Professors Marsh, Whitfield, and Emerson; to Mr. S. W. Loper, of Durham, Conn., whose enthusiasm in collecting and skill in developing such specimens as are found in his vicinity have resulted in contributing to several museums the best examples of our Triassic fishes known to exist; also to Mr. I. C. Russell, to whose intelligent supervision of the excavations made at Boonton, we owe the large amount and excellent condition of the material obtained there.

PART I.

GEOLOGICAL RELATIONS OF THE TRIASSIC ROCKS OF NEW JERSEY AND THE CONNECTICUT VALLEY.

GEOLOGICAL SKETCH.

The rocks which inclose the fossils described on the following pages occupy a series of detached areas extending interruptedly from Nova Scotia to North Carolina. They are in the form of basins, with their longest diameters northeast and southwest, parallel with the bearing of the ridges of the Alleghany Mountain belt Indeed, they seem to have been deposited in troughs lying between the most easterly and lowest of these ridges; troughs that were for ages occupied by fresh or brackish water lakes or estuaries, the surface drainage of the adjacent country.

After the Carboniferous age the whole region between the Mississippi and the Atlantic was raised above the ocean level, where it has remained with little variation of altitude to the present time. Of this belt of elevated country, which reached from the Green Mountains and the Adirondacks to the Gulf, the most easterly portion was much the older. This was formed by the Blue Ridge and the Hudson Highlands, with one or more parallel ridges on the east, which have since been depressed. The Alleghanies proper were added toward the close of the Carboniferous age. In Mesozoic times all this broad belt of highland was suffering erosion, and the material removed was carried away by the draining streams, both east and west, either in suspension or in solution. That which was dissolved flowed off into the somewhat distant oceanic basins, where it was deposited by organic agencies as limestone or flint, as it was lime or silica; while the suspended material was spread as sand, clay, and gravel over what are now the plains of the Mississippi Valley and what were then water-filled basins along the Atlantic coast. As I shall show farther on, the first of the Mesozoic strata to which we have access—composed of materials removed from the ancient

land mentioned above and spread round its margins—were laid down during the last half of the Triassic age, and a subsequent subsidence caused these to be covered by finer and more calcareous sediments during the last half of the Cretaceous age.

With the Mesozoic deposits of the interior of the continent we have now no immediate concern, as the task before us is to trace the history of those which accumulated on its eastern slope, and especially those formed during the Triassic age, viz: the shales, sandstones, and conglomerates, which were deposited in the lakes and bays already referred to. Of these Triassic areas the most northerly is that of Nova Scotia, about the Bay of Fundy, Princè Edward Island, etc. The second is that of the Connecticut Valley, which reaches from the north line of Massachusetts to Long Island Sound. The third, which may be called the Palisade area, extends from Rockland County, N. Y., to Orange County, Va., a distance of about three hundred and fifty miles. This area, which has the form of a long and narrow trough, is bounded on the west by the Blue Ridge, and on the east by the Archæan rocks of the Staten Island, Trènton, and Philadelphia axis.

In Virginia and North Carolina are several distinct and smaller basins lying eastward of the Palisade area, some of which contain coal beds of economic value. The Triassic rocks which fill these basins are alike in this, that they consist chiefly of beds of conglomerate, sandstone (sometimes arkose), and shales, interstratified with heavy beds of diabase. The prevailing color of both sandstones and shales is red or reddish, but the Connecticut area includes layers of nearly black shale charged with carbonaceous matter, containing many remains of fishes and plants, and even some thin films of coal. Also a small part of the series in New Jersey consists of dark or dove colored shales charged with organic matter, sometimes crowded with the remains of fishes, and exhaling a marked bituminous odor when struck with a hammer. It should also be said that a small detached basin of Triassic rocks in Southbury, Conn., includes a thin sheet of impure limestone.

The sandstones of the series are frequently firm and massive, and are extensively used as building stone, important quarries having been for many years worked at Long Meadow, Mass., Portland, Conn., and Newark, N. J.

These quarries have furnished much of the building material employed in our cities, and the fronts of fully one-half of the residences of New York are composed of "brownstone," as it is called, derived from them.

The thickness of the Triassic series in the Connecticut and Palisade areas is 5,000 feet or more, and the arrangement of the strata among themselves is peculiar and as yet not satisfactorily explained. In the Connecticut area the rocks all dip toward the east, the outcropping edges of the trap sheets left in strong relief by the erosion of the associated beds forming the bold escarpments of East Rock and West Rock, at New Haven, Conn., Mount Tom and Mount Holyoke, in Massachusetts. In New Jersey, on the contrary, the dip of the Triassic beds is generally towards the west at an angle of from three to fifteen degrees with the horizon, and the edges of the trap sheets form bold cliffs, which face the east and constitute the summit of the ridges known as the Palisades, First and Second Newark Mountains, etc. In addition to these sheets of trap the strata are cut by many dikes of diabase, which cross them vertically or at a high angle.

The origin of the singular structure I have described has been much discussed. Many of the beds show ripple-marks, sun cracks, and rain-drop impressions, which prove that they were once beaches or mud flats, sometimes exposed to the air. They are also frequently impressed by the tracks of large and small animals, generally three-toed, but sometimes showing four or five digits. These were at first supposed to be for the most part the tracks of birds, but are now believed to have been made by reptiles and amphibians. We have here autographs of perhaps one hundred different kinds of animals of which scarce any other record has been discovered, a few scattered bones and one or two imperfect skeletons being all yet found of the creatures themselves. Everything indicates that these tracks were made by animals that frequented the shores of bays and estuaries where the retreating tide left broad surfaces which were their feeding grounds. Inasmuch as many successive beds show ripple-marks, sun cracks, and tracks, the conclusion seems inevitable that the areas where these strata were deposited were slowly sinking and that the land-wash spread by the tide constantly formed new sheets, upon which fresh records were inscribed. The downward movement must have been very slow, for it apparently about

kept pace with the accumulation of material; but it was not regular, as we find alternations of conglomerate, sandstone, and shale, which were deposited in water of different depth. The uniform dip of the Triassic strata in each basin and the opposite inclination of those in the Connecticut and the Palisade areas have been variously explained. One theory proposed by Prof. H. D. Rogers[1] is that the strata were laid down upon a slope. This theory might be true of the coarse material deposited along an inclined shore, but could hardly be applicable to the finely laminated shales and limestones which accumulated in deep water.

Another view, advocated by Mr. I. C. Russell[2] is that the Triassic basins of the Connecticut Valley and New Jersey were once connected, and the strata were deposited continuously over all the area between them; that subsequently the central portion of this area was elevated and the Triassic rocks were eroded from it, leaving the two sunken margins occupied by beds which rise respectively from the east and west towards the central elevated area. Mr. Russell has studied the structure of the Triassic area of New Jersey with much care, and in his paper he presents many facts and a strong array of arguments in favor of his theory. There are, however, two difficulties which suggest themselves and call for further investigation of the problem before we can accept this solution. These difficulties are—

First. Not a trace of Triassic rocks is now anywhere visible in all the broad belt between the Hudson River and the Connecticut Valley, and it seems scarcely possible that if they once covered this belt to the depth of many thousand feet they should have been so completely removed.

Second. It has been found that on western Long Island, opposite the center of the New Jersey Triassic area, the crystalline rocks, which are a continuation southward of those lying between the Hudson and the Connecticut, are covered unconformably by Cretaceous strata, with no Trias between them. This would indicate that the Trias of the New Jersey basin never reached over that portion of the divide.

Still another theory has been proposed by Prof. W. M. Davis to account for the structure of the Triassic beds of the Connecticut Valley. This

[1] Final Report, Geology of New Jersey, 1840, pp. 166–171.
[2] Annals New York Academy of Sciences, vol. i, p. 220.

was presented by him to the geological section of the American Association at its meeting at Buffalo, in 1886, and was subsequently published in the American Journal of Science for November of that year. This theory supposes that the Triassic rocks were once deposited horizontally, or nearly so; that the trap sheets were overflows and not intrusive, and that all were broken and inclined by a series of faults, the result of lateral pressure; this pressure affecting primarily the underlying crystalline rocks, which, standing nearly vertical, slipped on each other, causing a series of fractures and uplifts along their lines of strike. Professor Davis has worked out this theory with much ingenuity and ability, and, if it shall be found upon further examination that the series of faults which he depicts do really traverse the Triassic rocks, we shall be indebted to him for the solution of what has been one of the most difficult problems in American geology. But there are some facts which are apparently incompatible with its universal application. No such faults as Professor Davis supposes to exist are discoverable in the localities I have had an opportunity of examining since the promulgation of his views, viz: along the Palisades, and at East Rock and West Rock, New Haven; and some of the trap sheets are certainly intrusive, having baked the beds on both sides of them.

The materials of which the Triassic beds are composed are all presumably, and in part at least demonstrably, derived from the adjacent highlands. In New Jersey the conglomerates are made up of rolled fragments of the granitoid rocks of the neighboring hills, and the sandstone, arkose, and shale apparently represent the different stages of mechanical decomposition of the quartz and feldspar of the granite. The New Jersey highlands, as well as other portions of the Blue Ridge belt, are known to contain great quantities of iron ore, and the erosion of the gneiss which forms this belt must necessarily result in the distribution of a large amount of iron Hence it is not surprising that the shales and sandstones all contain enough of this element to give them a red or reddish color whenever it is in the form of the anhydrous peroxide. The fact that it is generally in this condition, and therefore that the rock is red, proves that it contained little or no organic matter when deposited; for whenever decaying organic matter is present in any considerable quantity it reduces the peroxide of

iron to protoxide, and makes the color, so far as influenced by the salts of iron, gray, green, or blue. Where the organic matter is in very large quantity it imparts the characteristic color of carbon, and makes the shale or limestone which contains it black.

The general absence of organic matter in the Triassic rocks is doubtless due to the circumstances under which they were deposited; that is, in brackish water, which is always unfriendly to life, and perhaps was subject to high tides, which caused physical commotion, another unfavorable condition. We can imagine the circumstances attending the accumulation of the Triassic sediments to have been somewhat like those which now prevail in the Bay of Fundy, where the advance and retreat of a bore, or very high tide, keeps the water always in violent motion and turbid, and the alternating extremes of ebb and flow forbid the occupation of the littoral zone by either animals or plants. The gray and blue shales of Boonton and Sunderland contain an abundance of organic matter, of which sufficient would be furnished by the fishes to partially deoxidize the iron deposited with them, while the black shales of Plainfield and Weehawken, N. J., and Durham, Conn., are colored simply by the abundance of carbonaceous matter. An illustration of the truth of the views here proposed is found in the difference between the colors prevailing in the Palisade area and the Richmond basin. In the former the rocks are, as has been stated, generally very barren of fossils and the color is mostly reddish, while in the latter the quantity of organic matter is large and the color of the rock is blue, gray, or black.

GEOLOGICAL EQUIVALENTS OF OUR TRIASSIC ROCKS.

The age of the series of rocks which have been called Triassic on the preceding pages has been much discussed. Maclure considered them the equivalent of the Old Red Sandstone of Scotland, being influenced by the similarity of their lithological characters.

Mr. Richard C. Taylor, for a time at least, entertained the opinion that the group of rocks we are now considering belonged to the Coal Measures, being led to this conclusion by the presence of coal beds in the Richmond basin and the general resemblance to the Coal Measures of Pennsylvania exhibited by the associated rocks. A single one of the abundant fossil

plants which occur in the Richmond coal basin would, however, have been sufficient to show the error of this opinion.

Prof. Edward Hitchcock, who was one of the earliest to consider the subject, arrived at the conclusion that our Red Sandstone series was the equivalent of the New Red Sandstone of Europe. To this he was led mainly by the similarity of their lithological characters and their position relative to the Carboniferous rocks below and the Cretaceous above. He also mentions the discovery in these rocks of portions of a vertebrate skeleton which was not a fish, and he inferred from that fact that the series was Mesozoic, because at that time no animals of higher rank than fishes had been found in the Paleozoic rocks. We have since learned that amphibians are common in the Coal Measures, and the remains of reptiles are not wanting. At the time Professor Hitchcock wrote, the Permian and the Trias were not separated, but both were included in the so-called New Red Sandstone. This term was used to designate the group which, containing much Red Sandstone, rests on the Carboniferous, and to distinguish it from the Old Red Sandstone below.

So Professor Hitchcock supposed that we had in the rocks under consideration the equivalents of the Rotheliegende, as well as of the Bunter and the Keuper. The same view was taken later by Prof. Ebenezer Emmons in his Geological Report of the Midland Counties of North Carolina, 1856, page 273, receding from an earlier opinion (1853)—when he called the whole series Triassic—for the reason that in the lower portion of the Dan River section, North Carolina, he found the remains of Thecodont saurians. On the other hand, Profs. W. B. and H. D. Rogers were led by the general resemblance of the ferns and cycads of the Richmond basin to those of the Lias of Whitby, England, to consider these rocks Liassic, that is, Lower Jurassic. This view was also shared by Sir Charles Lyell when, in 1845, he visited the Richmond coal basin and collected a series of fossil plants, which were examined by C. J. F. Bunbury, who had given much attention to fossil botany.[1]

Prof. Jules Marcou, on his Geological Map of the United States, published in 1853, represents the New Red Sandstone of Virginia as Liassic,

[1] Quart. Jour. Geol. Soc. London, vol. 3, 1847, pp. 261-288.

but in his Geology of North America, 1858, he claims that the Richmond coal basin is of the age of the Keuper or Upper Trias, although he accepts the view of Professor Emmons, that the coal series of Deep and Dan Rivers, North Carolina, is at base Permian. On page 16 of the Geology of North America, Prof. J. Marcou publishes a letter of Prof. Oswald Heer, of Zurich, written July 25, 1857, in which he reviews the fossil flora of the Richmond and North Carolina coal basins, and regards it as contemporaneous with that of the Keuper.

In October, 1857, Sir Charles Lyell, writing to Professor Marcou (loc. cit.) quotes a note from Mr. Bunbury upon this subject, in which, referring to his paper on the Richmond plants[1] where he had expressed the opinion that the formation containing them might belong to the Jurassic or to the Triassic period, and that it might, with almost equal plausibility, be referred to either, he says: "At the time I wrote this the Basle and Baireuth beds were supposed to be Lias." Professor Marcou comments on this as follows: "As the Basle and Baireuth beds are now recognized by every geologist as belonging to the Keuper, it will appear that Bunbury never intended to put the Virginia coal field in the true Jurassic of England; so that we all agree to regard the Red Sandstone of Virginia and North Carolina as Keuper."

In 1883 Prof. W. M. Fontaine published the results of a careful study made by himself of the flora of the coal series of Virginia in a monograph issued by the U. S. Geological Survey, with the title "Contributions to the Knowledge of the Older Mesozoic Flora of Virginia." In this monograph (pp. 122, 123) he enumerates thirty-nine well-defined species of plants, of which 23 per cent. are peculiar to North Carolina, 41 per cent. are found in Virginia, 20 per cent. are allied to or identical with Jurassic forms while the number of species identical with or allied to Rhætic plants amounts to 38 per cent.; or, as he says:[2]

> Assuming with Feistmantel that the Rajmahal group of India is of Liassic age, we have two species identical with and six nearly allied to Jurassic plants, while seven species are identical with and eight closely allied to Rhætic plants.

This shows that the plant-bearing strata of Virginia and North Carolina may be safely considered equivalent in age to the Rhætic beds of Ger-

[1] Quar. Jour. Geol. Soc. London, vol. 3, 1847, p. 288.

[2] Op. cit., p. 123.

many; a result confirming and further illustrating the conclusions of Heer, Marcou, Bunbury, and others, who have regarded the Richmond coal series as Upper Trias. The Rhætic, formerly included in the Keuper, is known to form beds of passage between the Trias and the Lias, though with a still prevailing Triassic facies.

We are not yet in possession of the material necessary for making an exact comparison between the rocks of the southern Triassic areas and those of New Jersey and Connecticut. No considerable collection of the fossil fishes of the Richmond and North Carolina basins has been made, though they are known to abound there; but the few fish remains from North Carolina and Virginia which have come under my observation show that there are marked differences between the faunas of the northern and southern Triassic basins. On the other hand, the plants thus far collected in New Jersey and Connecticut are few—since they are not common in any locality yet known—while plants are by far the most striking and abundant fossils in the Virginia and North Carolina basins. They have been gathered by many collectors, and have been now studied by Professor Fontaine and described in the monograph referred to above. More fishes from the southern areas and more plants from the northern must therefore be collected before a satisfactory comparison can be made. So far as they throw light upon this subject, the facts already gathered indicate a general parallelism between the northern and southern areas; some differences, but many points of identity being discernible. For example, the Richmond coal basin has furnished to me one species of *Catopterus* (*C. gracilis*) which is common in New Jersey, but by far the most abundant fish of the Richmond basin is *Dictyopyge macrura* Egt., which has not yet been found in the northern basins. Traces of two other genera and species unknown at the North have been obtained from Richmond. It is probable that the large fish of which a fragment is figured by Sir Philip Egerton,[1] and called a *Tetragonolepis*, is an *Ischypterus*, identical with the large and broad species (*I. ovatus*) which occurs at Sunderland and Boonton. Whether the other species of fishes belonging to the genera *Catopterus*, *Ischypterus*, *Diplurus*, etc., found in the northern basins, will be obtained at the South when

[1] Quart. Jour. Geol. Soc. London, vol. 3, 1847, pl. 9.

they shall be carefully sought for, remains to be seen. A conclusive comparison cannot be made, however, till a thorough search for fishes is instituted in the southern basins; for, while we do not always find the things we seek, we make full collections of those fossils only which are the objects of special search.

A comparison of the fossil plants of the northern and southern basins is somewhat more satisfactory, and yet the limited number of species obtained at the North leaves the result of such comparison far from conclusive. Professor Fontaine, as has been mentioned, has enumerated about forty species of plants obtained from the Richmond and North Carolina coal basins. Among these perhaps the most abundant is the large monophyllous fern *Tæniopteris magnifolia* of Rogers, but this has not yet been found anywhere at the North, nor has any other similar fern been met with there. Another common plant at Richmond is *Schizoneura planicostata* (*Calamites planicostatus* of Rogers), and this I have found at Milford, N. J.; Durham, Conn.; and Sunderland, Mass. An allied plant is *Equisetum Rogersi*, Schimper (*Equisetum columnare* of Brongniart and Rogers). Professor Fontaine says:[1] "This plant is one of the most characteristic fossils of the Richmond coal field, and has a wide vertical and horizontal range." He further says that it is almost everywhere found with *Macroteniopteris magnifolia*, and that they form the only fossil plants of some localities. This plant is rare at the North, as I have obtained it from but one locality—Milford, N. J. Another common plant at Richmond is a fern, belonging to the genus *Clathropteris*, which Fontaine[2] identifies with *C. platyphylla* var. *expansa* Saporta, and with *C. rectiusculus* of Edward Hitchcock, jr., described in the American Journal of Science for July, 1855. This plant occurs rather abundantly at Durham, Conn., and at East Hampton, Mass. We find also at the former place a delicate and slender *Baiera*, which may not be distinct from that obtained by Emmons in North Carolina and figured by him in his American Geology, Part 6, page 133. Another common plant at Durham has a simple flattened stem from half an inch to an inch in width and sometimes a foot or more in length. This is apparently identical with that figured by Emmons,[3] and named by Fontaine *Bambusium Carolinense.*

[1] Mon. cited, p. 12. [2] Ibid., p. 54. [3] American Geology, part vi, p. 132.

Among the conifers apparently two or three are common to the northern and southern Triassic basins. *Palissya Braunii*, Endl., occurs in North Carolina, and a fine specimen of it is figured by Fontaine on Plate L of his monograph. I have a still finer specimen from the quarries at Newark, N. J., where it seems to be common; and, although the coarse sandstone has not often preserved the foliage, what I suppose to be portions of its trunks and branches are very numerous.

The plant which Fontaine considers identical with *Cheirolepis Münsteri*, Schimper, is found at Durham and many other places in Connecticut, as well as in Massachusetts and New Jersey. As I have shown in my notes on the Triassic plants, this is probably not a *Cheirolepis*, but a *Pachyphyllum;* but there is no question of its occurrence in all the northern and southern basins.

On the other hand, among the small number of plants from the Trias of New Jersey and Connecticut are two or three which have not yet been found at the South. Of these the most important is a species of *Otozamites*, which is rather common at Durham, but not yet found elsewhere. Its fronds are one to two feet in length by one to three inches wide. When it was first found, many years ago, I was unable to distinguish it from *Otozamites brevifolius* Fr. Braun, one of the most characteristic plants of the Rhætic beds of Bamberg, Baireuth, and other places. Recently Count Saporta has separated the larger fronds with narrow pointed pinnules from the smaller with shorter rounded pinnules (all of which were formerly attributed to *O. brevifolius*), and has made them the type of his species *Otozamites latior*.[1] These correspond precisely in size, form, and nervation with our Durham plant, and we may therefore accept this as another species common to our Triassic beds and the Rhætic of Germany and France, contributing an additional fact to the already sufficient proof of the parallelism that has been before reported.

The relations of the Triassic beds of the Atlantic coast to those of the interior and the western margin of the continent can hardly be established without larger collections of fossils from western localities. The Triassic strata underlying the Indian Territory, northern Texas, New Mexico, etc.,

[1] Paléontologie française, Végétaux, vol. 2, p. 130, Pls. 97, 98.)

are peculiarly barren of fossils. They are generally reddish sandstones, conglomerates, and shales below, with a series of highly colored indurated marls or fine-grained calcareous sandstones above, frequently charged with salt and sometimes including extensive sheets of gypsum. The sandstones are also conspicuously cross-bedded, and it is evident that the whole series was deposited in a shallow sea, swept by strong currents or high tides, and that bays, estuaries, or lagoons were formed at various times, in which the water was evaporated and its salt and gypsum were precipitated. These conditions were unfavorable to the presence of animal or vegetable life: as consequences, we rarely find any fossils in the beds, and the iron they contain is peroxidized, imparting to them their characteristic red color. This great sheet of Triassic rocks originally extended to the Wasatch Mountains, which formed the western shore of the sea in which they were deposited.

Passing over hundreds of miles where these Triassic rocks were just beneath the surface and freely exposed in cliffs and stream beds, I have sought for months in vain to find in them any traces of life; yet in two localities which I visited I was more successful, and from a third I have received a large collection of fossil plants. These localities are San José, near Pecos, in New Mexico, the old copper mines above Abiquiu, and Los Bronces, on the Yaki River, in Sonora. At the first locality are found *Walchia* and *Calamites* below, which mean Permian, and in softer beds of sandstone above—doubtless Triassic—impressions of fern fronds too indistinct for determination.

In the roof shales of the old copper mines near Abiquiu plants are abundant, but the number of species is small. Of these the most common and conspicuous is an *Otozamites* with broad truncated pinnules, which I have called *O. Macombii;* another cycad less common is a *Zamites* (*Z. occidentalis* Newb.), while twigs and cones of *Pachyphyllum* are occasionally seen. At Los Bronces the number of species is much larger, and we find among them several which occur in North Carolina, and one of those obtained from Abiquiu (*Otozamites Macombii*). The Carolina species are *Pecopteris bullatus* Bunbury (*Mertensides bullatus* Fontaine), *Pecopteris falcatus* Emmons (*Laccopteris Emmonsi* Fontaine), and *Tæniopteris magnifolia* Rogers. These indicate a parallelism between the plant-bearing beds of the Atlantic

Trias and those of New Mexico and Sonora, and go far to prove that all our Triassic rocks which have yet yielded plants belong to the uppermost division of the system.

In New Mexico there are at least two thousand feet of sandstones and shales belonging to the Trias beneath the strata which contain the fossil plants at the copper mines. Immediately above the latter lie the sandstones of the Dakota group, the basal member of the Cretaceous system as represented in that region; so that we have proof that these plant beds form the extreme upper part of the Trias. The lower beds of sandstone and the conglomerate which forms the base of the series in New Mexico and Arizona may represent the lower portions of the Trias in the Old World, but unfortunately no fossils have yet been obtained from them.

Many writers upon the Triassic beds of the West have called the whole formation Jura-Trias, either under the impression that both systems were represented in the group, or as a matter of precaution in case this should be found to be true. There seems, however, to be no good reason for thinking that the series of rocks which I have described represents the Jurassic of Europe. Another set of beds overlying the Triassic and underlying the Dakota sandstones occur in Utah, Colorado, and Wyoming, and are proved by their fossils to be Jurassic. But these beds wedge out toward the south, and I have been unable to find any traces of them south of Enchanted Springs, near the lower line of Colorado. They consist of—

(1) Gray earthy limestone with marine Jurassic mollusks, best shown in Wyoming and Utah.

(2) Light sandy and gypsiferous strata which succeed the limestone toward the south, and

(3) Alternations of reddish sandstones and shales—fresh-water beds, containing unios and saurian bones—the Atlantosaurus beds of Marsh.

On this series rest the Dakota sandstones, and below it are the red sandstones and conglomerates of the Trias.

PART II.

FOSSIL FISHES OF THE TRIASSIC ROCKS OF NEW JERSEY AND THE CONNECTICUT VALLEY.

FOSSIL FISHES.

The fishes of our Triassic rocks, though so far as yet known representing but six genera and about twenty-five species, are locally very numerous and are found in many localities. They were among the first fossils which attracted the attention of American geologists, and were referred to by Mitchill, De Kay, and Hitchcock half a century ago. Some imperfect specimens, obtained in the Connecticut Valley, near Amherst, were sent by the latter to Professor Agassiz when he was publishing his great work on fossil fishes. He figured and described two species, one of which he referred to the genus *Palæoniscus* and named *P. fultus;* the other he considered a *Eurynotus* and called it *E. tenuiceps.* About this time Mr. W. C. Redfield, of New York, began the study of these fishes. In connection with his son, Mr. J. H. Redfield, he published many notices of them during the succeeding twenty years. The first formal description of any of them was in a paper read by Mr. J. H. Redfield before the Lyceum of Natural History of New York, December 12, 1836, and subsequently published.[1] It contains figures and descriptions of two species, *Catopterus gracilis* and *Palæoniscus latus*, the former being made the type of a new genus. In 1841 Mr. W. C. Redfield read before the Yale Natural History Society a paper entitled "Short Notices of American Fossil Fishes." This contains descriptions of five species of *Palæoniscus*, three of which were then for the first time characterized, viz: *P. fultus* Ag., *P. latus* J. H. R., *P. macropterus* W. C. R, *P. Agassizii* W. C. R., and *P. ovatus* W. C. R.; also,

[1]Annals Lyceum Nat. Hist. N. Y., pt. 7, vol. 4, 1848, p. 35.

four species of *Catopterus* were described, viz: *C. gracilis* J. H. R., *C. macrurus* W. C. R, *C. anguilliformis* W. C. R., and *C. parvulus* W. C. R.[1]

In 1854 Mr. J. H. Redfield read to the Association of American Geologists and Naturalists a paper entitled "A Catalogue of the Fossil Fishes of the United States as far as Known, with Descriptions of Those Found in the New Red Sandstone." In this paper four species of *Catopterus* and nine species of *Palæoniscus* were enumerated; of the latter four, viz, *P. clupeiformis*, *P. rostratus*, *P. tenuis*, and *P. parvus*, had not been before described. This report has never been published, because, as I was informed by Mr. W. C. Redfield, it was agreed between Professor Agassiz and himself that the whole subject should be reviewed in a joint monograph. Unfortunately this was not done, and the death of Mr. Redfield in 1857 prevented further publication of the large amount of valuable information which he had acquired on this subject.

In 1847 Sir Charles Lyell published a paper[2] on the Coal Field of Eastern Virginia, in which he gave some notes on the fossil fishes he obtained there, with two beautiful plates, drawn by Joseph Dinkel. These notes also include the results of an examination of these fishes by Sir Philip Egerton, who reported (1) that the fish described by W. C. Redfield under the name of *Catopterus macrurus* should be considered the representative of a new genus "because it was homocercal," and he called it *Dictyopyge;* (2) that the fishes from the American Trias referred by Agassiz and Redfield to *Palæoniscus* were generically distinct, and he named the new genus which he created to receive them *Ischypterus*, because of the great strength of the fin rays. Sir Philip Egerton also decided that some of the specimens of *Catopterus* brought back by Sir Charles Lyell were different from *C. gracilis*, and suggested the name of *C. Redfieldi* for one of them.

A portion of the middle of the body of a large fish with quadrangular scales which Sir Charles Lyell brought from Blackheath, Va., he referred to the genus *Tetragonolepis*, but on scarcely satisfactory grounds.

Taking up the study of the fishes of the Trias soon after coming to New York in 1866, I had excavations made at Boonton, N. J., from which many hundreds of fishes were obtained, in circumstances which apparently throw

[1] Am. Jour. Sci., vol. 41, 1841, p. 24.
[2] Quart. Jour. Geol. Soc. London, vol. 3, 1847, p. 261.

some light on the manner in which they were entombed. This locality is near the western margin of the Triassic area where strata of shaly sandstone rest upon coarse conglomerate, showing the different conditions which prevailed at the same locality within a limited interval of time. Certain layers of the shales are crowded with fishes, a slab a yard square carrying sometimes a half dozen or more. Some of these are dismembered, consisting of a shapeless aggregate of scales and bones, but most are nearly perfect; and the number found at about the same level, with their perfection of preservation, seem to show that the generation inhabiting that portion of the Triassic basin at a certain time were somewhat suddenly killed and sunk to the bottom, where they were soon covered with the accumulating sediment and were thus preserved. The layers of the shale which contain the largest number of fishes are impregnated with bituminous matter, burning for a time when thrown into the fire, and when struck with a hammer giving off a peculiar odor. Similar fish beds are known to exist at Pompton, Plainfield, and beneath the trap of the Palisades above Hoboken, and it seems probable that the great mortality which strewed the bottom of the basin at times with dead fishes was the result of some phase of the volcanic action which poured out the trap masses of the Palisades and Newark Mountains.

Fishes seem to be equally abundant in the Connecticut River basin. At Durham, Conn., and Turner's Falls, Mass., they are particularly numerous and well preserved, while they have also been obtained at Middletown, Sudbury, Chicopee, Amherst, and Hadley's Falls. Collections made at all these localities have been studied by me, and among them I have identified with more or less confidence about twenty-five species. To the list of the species of *Catopterus* and *Ischypterus* enumerated by the Messrs. Redfield perhaps as many more have been added, and two genera which they do not seem to have met with, viz, *Diplurus* Newb. and *Ptycholepis* Ag. These will be found figured and described in another part of this memoir. In the revision of the group of fishes studied by the Messrs. Redfield access has been had to the specimens left by Mr. W. C. Redfield, most of which were donated to the Peabody Museum at Yale College. The collection contains many types of the species described by the Messrs. Redfield, but unfortu-

nately not fully labeled. It is also to be regretted that some of their types and many specimens which they had studied and labeled perished in the destruction by fire of the geological collection belonging to the New York Lyceum of Natural History.

I give below a list of the fishes of the North American Trias as far as yet made out. It probably includes nearly all the species which lived in the water basins from which the Triassic strata were deposited in New Jersey and the Connecticut Valley, but in the southern extension of the Triassic belt some new things are sure yet to be found. No one has given special attention to the fishes of the Richmond coal basin or those of North Carolina, but the few specimens which have been incidentally collected indicate considerable differences between the fish fauna of this region and that which I have studied farther north. By far the most common fish in the Richmond basin is *Dictyopyge macrura* Egt. (*Catopterus macrurus* W. C. R.), which I have not found elsewhere. With this are associated fragments of some other genera and species which have not yet been described. One of these is apparently a *Dictyopyge* considerably larger than *D. macrura*, and distinguished from it by having the flattened fin rays ornamented with raised lines. One new genus of which I have seen fragments is strongly marked by its relatively large, rounded, and ornamented opercula.

In the Triassic strata of the Far West very few fish remains have been found. Mr. E. E. Howell obtained from the Trias in southeastern Utah some detached ganoid scales, and recently Mr. R. C. Hills found at San Miguel, in southwestern Colorado, near the middle of the Triassic series of that region, several specimens of a *Catopterus* hardly distinguishable from *C. gracilis*, but too imperfectly preserved for accurate determination. Probably when the calcareous beds which represent the Trias in Idaho shall be more carefully examined they will be found to contain the remains of fishes which may be expected to resemble those of the Muschelkalk of Europe.

LIST OF TRIASSIC FISHES.

Diplurus longicaudatus Newb.
Ptycholepis Marshii Newb.
Dictyopyge macrura Egt.
Acentrophorus Chicopensis, n. sp.
Catopterus Redfieldi Egt.
gracilis W. C. R.
anguilliformis W. C. R.
parvulus W. C. R.
minor, n. sp.
ornatus, n. sp.
Ischypterus fultus Ag. sp.
macropterus W. C. R.
ovatus W. C. R.
Agassizii W. C. R.
Ischypterus latus J. H. R.
micropterus, n. sp.
alatus, n. sp.
modestus, n. sp.
parvus W. C. R.
Marshii W. C. R.
minutus, n. sp.
Braunii, n. sp.
robustus, n. sp.
tenuiceps Ag.
elegans, n. sp.
lenticularis, n. sp.
lineatus, n. sp.
gigas, n. sp.

DESCRIPTIONS OF GENERA AND SPECIES.

SUBCLASS GANOIDEI.

ORDER LEPIDOSTEIDÆ.

FAMILY LEPIDOTIDÆ.

Genus ISCHYPTERUS Egerton.

Under the names of *Palœoniscus fultus* and *Eurynotus tenuiceps* two species of this genus were described by Agassiz.[1] Previous to that time a specimen had been sent from Massachusetts to M. Alexandre Brongniart, at Paris; this was examined by De Blainville, and was referred to his genus *Palœothrissum*, for which *Palœoniscus* was afterwards substituted. All these specimens lacked important parts, were distorted and imperfectly preserved; hence it is perhaps not surprising that their anatomical structure was misunderstood, and they were included in genera to which they do not belong. *Eurynotus* is a palæoniscoid genus, restricted to the Lower Carboniferous strata, having a different arrangement of the head plates, a high, broad dorsal, and a very heterocercal tail; features in which it differs essentially from the fishes now under consideration. *Palœoniscus* also has been clearly shown by Dr. R. H. Traquair, in his admirable studies of the family,[2] to be as distinctly separated from them. In 1841 Mr. W. C. Redfield published an article with the title "Short Notices of American Fossil Fishes."[3] In this paper he describes five species of *Palœoniscus*, accepting the classification of Agassiz, who had referred them to this genus. These were *P. fultus* Ag.,

[1] Poissons Fossiles (vol. 2, p. 43, pl. 8, figs. 4, 5; p. 159, pl. 14c, figs. 4, 5, 1833–1843.)

[2] Quart. Jour. Geol. Soc., London, vol. 33, 1877, pp. 548–578, and Trans. Roy. Soc., Edinburgh, vol. 29, pp. 343–391.

[3] Am. Jour. Sci., vol. 41, 1841, p. 24.

P. latus J. H. R, *P. macropterus* W. C. R., *P. Agassizii* W C. R., and *P. ovatus* W. C. R. Mr. Redfield in this article pointed out some of the peculiarities of this group of fishes, and suggested that they should perhaps be separated from *Palæoniscus*.

This was subsequently done by Sir Philip Egerton,[1] who, on account of the great strength of the fin rays, named the genus which he created to receive them *Ischypterus*. Unfortunately no detailed description of the anatomical characters of the genus was given by Sir Philip Egerton, as he scarcely had sufficient material for the purpose. This is much to be regretted, as with his great knowledge, if he could have made a careful study of good specimens, he would have been led to discover and report the true relationship of the group. This is plainly with *Lepidotus* and its allies, and not with *Palæoniscus*, as supposed by Agassiz; an error into which he was led by the imperfect preservation of the fishes he examined, none of which showed any details of the all-important structure of the head. The head was small, and all the bones were delicate; hence the almost universal deficiences in this part of their structure when fossilized. Among the many hundred specimens of *Ischypterus* I have passed in review I have found a few in which nearly all the details of the bony structure were preserved, and I am able to describe this more fully than has before been possible, and to deduce from it with certainty the zoological relations of this group of fishes. Where distinctly visible the structure demonstrates an intimate relationship with *Lepidotus*, *Dapedius*, and *Pholidophorus*, but most of all with *Semionotus*. Here the affinity is so close, that it is probable that both Agassiz and Sir Philip Egerton would have united *Ischypterus* with that genus if the material at their command had been more abundant and better. In an examination of nearly all the specimens of *Ischypterus* contained in the museums of the United States and a considerable number of individuals of *Semionotus* I have been unable to detect any characters by which they can be distinguished. The outlines, size, and proportions of the body are essentially alike; both are elliptical or ovoid, with a relatively small, pointed head, and weak, scarcely lobate tail. The positions, form, and structure of the fins are so nearly alike that the differences can hardly be regarded as of more than specific value.

[1] Quart. Jour. Geol. Soc. London, vol. 6, 1850, p. 8.

The fin rays are few, broad, and undivided below in both; the anterior rays are characteristically strong; the fulcra few, strong, acute, and closely appressed; in both a row of large, sometimes erect and pointed scales marks the line between the head and the dorsal fin. The obliquity of the posterior extremity of the body is about the same; the mouth is small, the mandibles and maxillaries are weak, the premaxillaries united in a uniform arch, set with an even row of small, abruptly pointed teeth, as are also the maxillaries and mandibles; and the eye is placed above the posterior margin of the mouth. The divisions and the forms of the head plates are apparently the same, though I have not been able to verify by personal examination the descriptions of the head plates of *Semionotus* given by European authors. I can not, therefore, assert that *Semionotus* and *Ischypterus* should be united. I call attention, however, to the close, general, and special resemblances between them, and leave to those who may have better opportunities for studying the structure of *Semionotus* the decision of the question.[1]

The specific division of the great group of fishes representing the genus *Ischypterus* obtained from the Upper Triassic rocks of New Jersey and the Connecticut Valley is a matter of no little difficulty. The descriptions given by Mr. W. C. Redfield in the article mentioned above are exceedingly brief, and in the absence of the type specimens, which cannot now be certainly identified, it often becomes a matter of much doubt as to what were the fishes to which he applied these names. Only one has yet been figured, *Ischypterus latus* J. H. R., and this lacks both head and tail. In examining the collection of Triassic fishes left by Mr. W. C. Redfield, now at Yale College, and to which I have had access through the courtesy of Prof. O. C. Marsh, I found many without labels, and those which were named were in some cases so imperfectly preserved, that it was not easy to use them as guides in classifying the much larger number of specimens contained in the cabinet of Columbia College.

[1] Since the above notes were written two interesting papers have been published on the Triassic fishes of the Old World, viz, "On the Remains of Fishes from the Keuper of Warwick," by E. T. Newton, Rev. P. B. Brodie, and Edward Wilson, Quar. Jour. Geol. Soc., August, 1887, and "On Two New Lepidotoid Ganoids from the Early Mesozoic Deposits of Orange Free State, South Africa," by A. Smith Woodward, Quart. Jour. Geol. Soc. London, May, 1888. In both papers these fishes are described as species of *Semionotus*, which, if found in our Triassic rocks would be unhesitatingly referred to *Ischypterus*.

On the following pages, so far as I have been able, I have enumerated and defined all the species of the genus which have come under my observation. I deem it necessary to say, however, that future observations will probably diminish rather than increase the number of forms in which the differences should be given specific value. For example, *I. alatus* may prove to be only a variety of *I. lineatus* and *I. modestus* a phase of *I. elegans;* but with marked differences and without connecting links, so far as yet observed, it has seemed to me hardly justifiable without further evidence of identity to unite them under a common name.

Ischypterus ovatus W. C. R.

Pl. I, Fig. 1.

Palæoniscus ovatus W. C. R., Am. Jour. Sci., vol. 41, 1841, p. 26.

The only published description of this species is that cited above. It reads as follows:

Palæoniscus ovatus W. C. R.—Wide or round-shaped Palæoniscus. This species is shorter than *P. Agassizii*, and exceeds all the known American species in the comparative width or roundness of its form, and is also remarkable for the large size of its scales. It is of rare occurrence, and, owing probably to its great thickness, is seldom obtained in perfect form. This fossil also exhibits the spine-like erections of the dorsal scales which have been noticed above.

Found at Westfield and Middlefield, Conn.; Sunderland, Mass., and Boonton, N. J.

In the manuscript report of Mr. J. H. Redfield the following notes on this species appear:

Fish ovate; head rather small and narrow; body widening rapidly from the head to the dorsal and ventral fins, expanding as far as the ventral fins, from which point the form gradually narrows to the pedicel of the tail. Scales large, anterior ones concentrically striate, those of the dorsal ridge pointed and elevated as in *P. tenuiceps;* pectoral fins small, comparatively slender; ventrals small; dorsal large, rays strong; anal not well observed. This is the broadest and most ovate species of *Palæoniscus* that is known, and perhaps ought to be referred to a separate genus. In the size of the scales it resembles *P. Agassizii*, but its form will readily distinguish it.

In the collections made at Turner's Falls, Mass., and Boonton, N. J., I find a large species of *Ischypterus*, which agrees very well with the descriptions given above. The fish reaches a length of from ten to twelve inches, is ovoid in form, with a breadth at the dorsal fin of from four to five inches;

all the fins are quite strong, and the scales are large, broad, and thick. The concentric lines upon their borders, mentioned by Mr. J. H. Redfield, are not peculiar to this species, but are more or less distinctly visible in all the members of the genus in certain states of preservation. It is most noticeable where the scales are partially decomposed and where they were of considerable thickness. In outline the fishes of this species resemble some individuals of *Ischypterus tenuiceps*, but they are considerably larger, the scales are also relatively larger and more quadrate; the arch of the back is usually regular, and the outline is comparatively smooth, never showing the extreme development of the dorsal scales which is so conspicuous a feature in the older individuals of *I. tenuiceps*.

Judging from some of the specimens obtained from Turner's Falls, I am inclined to think that this is the fish which is figured by Sir Charles Lyell in his paper on the Virginian coal field and referred to by Sir Philip Egerton as a species of *Tetragonolepis*. In that specimen nothing is shown but a portion of the side near the head, without tail or fins. If the fins had been present they would probably have shown the great development of the fulcra, which is characteristic of *Ischypterus* and wanting in *Tetragonolepis*. This I infer from the facts that no other traces of the latter genus have been found in the Triassic rocks of North America, and the scales on the sides of the large and broad species of *Ischypterus* could hardly be distinguished from those of a corresponding part of the body in *Tetragonolepis*. With precisely similar scales, however, we have in several instances the characteristic fins of *Ischypterus*. No such specimens were contained in the collections made by Sir Charles Lyell in America, and the inference of Sir Philip Egerton was therefore a natural one, though probably erroneous.

Ischypterus Marshii W. C. R.

Pl. II, Fig. 1.

Fishes twelve inches or more in length by three or four inches in breadth; body fusiform in outline; head conical, obtuse, contained four and one-half times in the entire length; fins strong but relatively short; anterior base of dorsal midway between muzzle and tip of tail; fulcra strong and short; rays

eight (?); caudal fin strongly forked, three inches wide in fish twelve inches long, unsymmetrical, upper lobe longest; scales universally large and thick; those of dorsal line less strongly spined than in other large species of the genus; boat-shaped scale covering anterior base of dorsal fin relatively small, rounded before, pointed behind, not notched; rows of scales on sides more oblique than in other large species; those on the middle and anterior portions of the body square or oblong, slightly higher than broad.

This large and fine species was named by W. C. Redfield, but was never described. It is referred to in his paper,[1] and I find a specimen from Sunderland, Mass., bearing this name in the Redfield collection at Yale College. In pursuance of my plan to secure to W. C. Redfield all the fruit of his labor in this field I have adopted it, and now supplement the name with a detailed description.

So far as known this species only occurs at Sunderland, Mass., where a number of fine specimens have been procured, one of the best of which may be seen in the American Museum of Natural History, New York, to which institution, with many other fossil fishes, it was presented by the late Robert L. Stuart. This, like a number of others which I have seen, has a length of about twelve inches, but the species probably attained somewhat greater dimensions. The body is broadly or more narrowly fusiform, the widest portion being midway between the dorsal fin and occiput. In general form it resembles *Ischypterus Agassizii*, but attains greater dimensions and may be distinguished at a glance by the larger size of its scales and the more oblique position of the rows on the sides.

In general aspect this fish has much resemblance to some species of *Lepidotus*, all of which are characterized by their relatively large and thick scales. The resemblance of *Ischypterus* to *Lepidotus* has been referred to, and it is evident that they are closely allied, but as a whole the species of the former genus are smaller and are distinguished by the more salient row of spiny scales along the dorsal line, and by a greater prolongation of the upper lobe of the tail.

[1] Proc. Am. Assoc. Adv. Sci., Albany meeting, 1856, pt. 2, p. 188.

Ischypterus Agassizii W. C. R.

Pl. III, Fig. 1.

Palæoniscus Agassizii W. C. R., Am. Jour. Sci., vol. 41, 1841, p. 26.

The first notice of this species was given by W. C. Redfield in the article cited above. The description which he there published is as follows:

Its length in the specimens hitherto obtained varies from seven and one-half to ten inches, and its width from three to four inches. The fins, with their armatures and insertions, are also of more remarkable thickness than in the species already noticed. The large scales or plates which belong to the anterior portion of the dorsal line are commonly found doubled together at their lateral edges by the incumbent pressure, which gives them the appearance of short spines or flattened rays; and hence these are sometimes mistaken for an anterior comb-like dorsal.

Mr. J. H. Redfield, in the manuscript report to which reference has been so frequently made, adds the following notes upon this species:

Head narrow and pointed, scales large and smooth, sometimes with faint concentric striæ; those of the anterior portion of the dorsal ridge very much elongated, strong and pointed, and apparently erectile; when in an erect position much resembling rays, and giving the appearance of a comb-like dorsal fin; back arched, but not so abruptly as in *P. tenuiceps*. The widest portion of the fish is found just anterior to the ventral fin; pectoral fin moderate; anterior raylets rather short; primary rays six or eight; ventral fins small, anterior raylets about ten; primary rays about five or six; dorsal fins large, triangular, preceded by erect, pointed scales; anterior raylets very long, twelve or more in number; primary eight to ten; anal fin large, but not so much elongated as in *P. tenuiceps* or *P. fultus;* anterior raylets very strong, about twelve in number, primary rays six to eight; tail forked, lobes acute, anterior raylets rather stout, rays of lower lobe much stouter than those of upper; length, seven to ten inches; breadth, three to three and one-half inches. Occurs at Sunderland, Mass., Westfield and Middlefield, Conn., Pompton and Boonton, N. J.

Among the fishes obtained at Boonton, N. J., are a dozen or more of unusually large size, and manifestly distinct from the many small fishes with which they are associated. These I have supposed to be the fishes to which W. C. Redfield gave the above name, and indeed there are no others found at that locality to which his description is at all applicable.

These fishes are from ten to twelve inches in length and from three to three and a half inches wide. The head is conical and pointed, and in an individual twelve inches long it has a length of three inches; the back is uniformly and rather strongly arched anterior to the dorsal fin; the row of dorsal scales is strong, though usually depressed, and when erected would present

the appearance of a comb-like crest described by W. C. Redfield. This row of scales is, however, less strongly developed than in *Ischypterus tenuiceps*, and the arch of the back does not show the hump which is so characteristic of that species; the fins are very strong; the fulcra of the dorsal and anal fins unusually broad and long, forming arches nearly half an inch wide at base, curving gracefully backward to a point; the anal fin when appressed reaches quite to the base of the caudal; the tail when expanded is three inches wide at its extremity; the scales of the sides are large and thick, those near the head square or oblong.

I have seen no such fishes as these anywhere except at Boonton. At Durham we find a species of *Ischypterus* of about the same size, but considerably broader—the mature form of *Ischypterus micropterus* N. At Sunderland occurs another species (*I. Marshii*) which in form and general aspect resembles those under consideration, but it is narrower, with less strong dorsal and anal fins, with thicker and relatively broader scales, which form more oblique rows on the sides. For these reasons I have thought it wise to regard it as distinct.

ISCHYPTERUS MICROPTERUS, n. sp.

Pl. IV, Figs. 1, 2; Pl. XII, Fig. 2.

Fishes of medium or large size, five to ten inches long by one and a half to three and a half inches wide; form conical, greatest breadth at pectoral fins, thence tapering uniformly to tail; back and abdomen about equally arched; head conical, acute, contained four and a half times in total length, nearly horizontal and straight below, rapidly sloped above; muzzle prolonged, acute; mouth very small; maxillary and mandible slender, teeth small, conical, acute; cranial plates granulated; operculum narrow; anterior margin vertical, posterior rounded, supraclavicles and clavicles slender; scales smooth, polished, oblong, twice as high as long on the sides near the head, rhomboidal on posterior portions of sides and tail; scales of anterior dorsal line about fifteen in number, rounded and emarginate at base, abruptly narrowed to smooth acute spines above; fins all relatively small and weak; anterior base of dorsal midway between tip of tail and extremity of muzzle; fulcra eight, relatively small; fin rays eight, narrow, delicate;

large scales of posterior dorsal line eight, elliptical before, elongate and spiny behind, running into fulcra of upper margin of dorsal, which are ten in number, eight beyond scaled extremity of body, all slender and rod-like; caudal fin narrow and weak, oblique, upper lobe longest, rays fifteen, slender; fulcra of lower margin fifteen; anal fin narrow, just reaching base of caudal, rays eight, fulcra ten.

The most striking diagnostic characters of this species are its pointed rostrate, depressed muzzle; conical narrow head, horizontal below; the wedge-shaped outline of the body, which is widest near the head; the small and delicate fins, and the narrow and oblique tail. The largest specimen which I have is ten and a half inches long by three and a half inches wide, the smallest five and a half by one and a half inches; but I have seen one specimen which shows distinctly all the characters of the species, and yet is only about three and a half inches long.

This is the most common species of *Ischypterus* at Durham, Conn., but I have not certainly identified it elsewhere. S. W. Loper has good specimens in his cabinet, and has supplied a fine series of different ages to the cabinets of Yale and Columbia.

The figures given on Pl. IV represent old and half-grown individuals; that on Pl. XII, Fig. 2, is still younger.

Ischypterus tenuiceps Ag., sp.

Pl. V, Figs. 1, 2, 3; Pl. VII, Fig. 3.

Eurynotus tenuiceps Ag., Poiss. Foss. vol. 2, p. 159, Pl. 14*c*, Figs. 4, 5; E. Hitchcock, Geol. Mass., vol. 2, p. 459, Pl. 29, Figs. 1, 2.

This species has been more fully illustrated than any other from the American Trias. Two figures of it are given by Agassiz in his Poissons Fossiles (loc. cit.); two are given by Professor Hitchcock in his quarto Report on the Geology of Massachusetts; one in Emmons's Geological Report of the Midland Counties of North Carolina, Pl. IX (reproduced in his American Geology, pt. 6), a wood-cut probably of this species in Emmons's Manual of Geology, page 188, and in American Geology, pt. 6, page 144; also, three figures of it are given on Pl. IX*a* of the latter work. Of these last cited figures only one has the normal form of the species, the

others being distorted and narrowed, but the originals were all from the same place, Turner's Falls, where this is the most abundant species, and they show the peculiar erect, thickened dorsal scales, which are not developed to the same degree in any other. Unfortunately all the figures of *I. tenuiceps* yet published are taken from imperfect specimens. That on Pl. IX of the American Geology, pt. 6, represents the posterior half of the body fairly well, but the head is a shapeless mass, and the arch of the back is only partially shown.

As mentioned in the remarks on the genus *Ischypterus*, the preservation of the head is so generally incomplete that we must conclude its bony structure was delicate and largely reënforced by cartilage. Out of the large number of specimens which I have, however, a few give the outlines of the head and much of its structure with considerable accuracy. From these we learn that it was conical, rapidly sloping from the high nuchal arch, and from the smallness of the mouth, pointed at the muzzle. The general form was ovate, in that respect resembling *Ischypterus ovatus* W. C. R., but the species may be distinguished generally at a glance by the high, thickened, and often obtuse scales which crown the humped back. The length of this species in mature individuals is eight inches and the breadth immediately behind the head is two and a half to three inches. The dorsal scales are often strangely thickened and distorted in the nuchal region, where they are sometimes more than half an inch long, clavate and blunt. This I was at first disposed to regard as the result of pyritous concretionary distortion, but I have seen it in so large a number that I am compelled to regard it as a specific character. In some cases the form of every scale of the row is observable; it is seen that those immediately back of the head are much elongated, and the terminal spine is depressed backward, so that the scale is blunt and club-shaped. Possibly this is the result of disease, but if so, it attacked a majority of individuals. More likely it is a character developed by age and only fully shown by those that were quite old at the time of their entombment. It is possible also that it is a sexual character; but, by whatever cause produced, it is a mark by which, when present, the species can be immediately recognized.

This species is found much more abundant at Sunderland, Mass, than elsewhere. Probably more than half of the individuals which have been taken from the Triassic rocks there belong to it. A few individuals have been obtained from Durham and Boonton which were regarded by W. C. Redfield as specifically identical with these. Of this there may be some doubt, since nowhere else are fishes found which have the back so highly arched immediately behind the head, and set with the long, divergent, acute or clavate scales.

The figures given on Pl. V represent two old individuals and one very young one. Fig. 3 of Pl. VII represents a mature but not old individual.

ISCHYPTERUS FULTUS Ag. sp.

Pl. VI, Fig. 2; Pl. VII, Fig. 1.

Palæoniscus fultus Ag., Poiss. Foss., vol. 2, p. 43, Pl. VIII, Figs. 4, 5.
Palæoniscus fultus W. C. R., Am. Jour. Sci., vol. 41, 1841, p. 25.
Ischypterus fultus Egerton, Quart. Jour. Geol. Soc. London, vol. 3, 1847, p. 277.

Two very imperfect fishes from Sunderland, Mass., both wanting the head and one the tail, served as a basis for Agassiz's description of this species. All that can be said about them is that they represent one of the smaller and narrower species of the genus *Ischypterus*, as defined by Sir Philip Egerton. But no one could positively assert, even with the specimens in hand, that they belonged to one or another of several species found in the Connecticut Valley and New Jersey. We are, however, better informed in regard to the fish accepted by the Messrs. Redfield as representing the species *I. fultus*. Mr. W. C. Redfield, in the article so frequently referred to,[1] makes the following remarks upon this species:

> *Palæoniscus fultus* Ag., the specimen figured by Professor Agassiz is destitute of the dorsal and head, as well as the upper portion of the body. The length was probably four and a half inches; but this is often exceeded in other specimens. The fins and their bony insertions appear stouter than in *P. latus*, but less stout than in some other species. Found at Westfield, Middlefield, and Durham, Conn., and Boonton, N. J.

In the report read before the American Association of Geologists and Naturalists at New Haven, in 1845, by Mr. J. H. Redfield, I find the following description of this species:

> Fish fusiform, head small, rather more than one-fifth of the whole length; back nearly straight, but slightly arched; scales of medium size, often with concentric striæ, which

[1] Am. Jour. Sci., vol. 41, p. 25.

are most apparent on the posterior edge; scales of the dorsal ridge pointed and erectile, but in a much less degree than in *Ischypterus tenuiceps;* pectoral fins small, narrow, and pointed; ventrals small, very narrow, and pointed; dorsal and anal fins both very long, with the anterior raylets very strong and rather numerous; primary rays of anal about seven, slender; anterior raylets about twelve, anterior raylets of dorsal about fourteen; tail forked, lobes more acute than in *P. tenuiceps;* accessary raylets long and numerous; length five to seven inches, breadth one and a half to two and a quarter inches. The specimens from which Agassiz constituted his *Palœoniscus fultus* were so imperfect, that it is difficult to decide with certainty which of our specimens should be referred to it. The character which he seized upon as its chief diagnostic, and on which he founded its specific name, *fultus*, viz, the extraordinary size of the anterior raylets of the fins, exists in all the known American species of this genus. We are not at all sure that we have rightly referred *P. macropterus* of W. C. R. to this species; for the specimens figured by Agassiz are represented with dorsal and anal fins which are far from having the length of these fins in *P. macropterus.* Those specimens were evidently imperfect, and it is well known how easily the frail and carbonaceous remnants of rays are detached from these fossils, sometimes leaving hardly a trace behind, and it is very possible that these portions were broken in the specimens which were figured by Agassiz. His name of *P. fultus* should in justice to him be retained, and since the long-pointed fins of the fish we have described above, strengthened as they are by large anterior raylets, will render the term *fultus* quite applicable, we think it advisable to restrict Agassiz's name to this species, and suppress *P. macropterus.* This species is characterized by the length of the dorsal and anal fins, which are even longer than in *P. tenuiceps,* from which species it is also readily distinguished by its form, the back not suddenly rising from the head as in that.

Among the fishes left by W. C. Redfield I find many which are labeled *Ischypterus fultus.* Most of these are from Boonton, and it is represented by him as the most common species found there. The form is rather narrow, the length from six to eight inches, the breadth never more than two inches at the widest part, which is half way between the dorsal fin and the head; the fins are relatively large; the tail is scarcely forked, but rather scalloped, with a broad and shallow sinus; the head is depressed, longer than wide, and about one-sixth of the entire length. From Durham and Sunderland I have specimens which I suppose must represent the fish named *P. fultus* by Agassiz, for his specimens were derived from the latter place. They are smaller than those from New Jersey, not over six inches in length by one and a quarter inches in breadth. It is quite possible that they represent a different species from that so common at Boonton, but that can only be shown by more extensive comparisons than I have been able to make.

The fish represented on Pl. VI, Fig. 2, is perhaps a fair example of the species so common at Boonton, and which W. C. Redfield first described as *Palæoniscus macropterus*. He afterward suppressed that name in deference to Agassiz's opinion that it was not different from those to which he had given the name *P. fultus*. Pl. VII, Fig. 1, represents a smaller fish, of which I have a large number of specimens, but I have considered these the young of the larger form referred to above.

Ischypterus robustus, n. sp.

Pl. VI, Fig. 1.

Fishes of medium or large size, eight inches or more in length by three in breadth anterior to the dorsal fin; outline ovoid; head large, narrowed, muzzle produced; dorsal fin very large, its anterior margin about the middle of the entire length and nearly twice as far from the posterior scaled extremity of the body as from the head; fulcra very numerous, strong, curved; rays eleven, very strong; caudal fin of moderate size, upper lobe longest; anal of moderate size; ventrals inserted nearly opposite anterior margin of dorsal; pectoral fins relatively long and broad; scales of dorsal line long, forming a prominent crest; those of sides broad and thick.

This is a robust and coarsely organized fish, most nearly allied to *Ischypterus ovatus* of Redfield, but distinguished by the great height, breadth, and strength of the dorsal fin and its anterior position. The pectoral fins are also longer and broader than in any other species that I have seen. The ventrals and anal are not well shown in the specimens before me, but are apparently delicate; the caudal is relatively narrow, the lower lobe nearly horizontal, the upper strongly elevated and produced.

The great height and breadth of the dorsal fin of this species bring it closer to *Semionotus* than any other of its congeners, and there is little doubt that if it had been found in the Mesozoic rocks of the Old World it would have been referred to that genus; indeed, it is now difficult to say by what characters it could be distinguished generically from some of the described species of *Semionotus*. The line of spine-like dorsal scales is somewhat more conspicuous, but this is only a matter of detail, since something of the kind is seen in all the species of that genus with which I have compared it.

The scales of this species are relatively large and strong, and it is evident that the fish was firmly and robustly organized; hence the name given it.

Up to the present time I have seen but two or three specimens, and these are all from Boonton, N. J.

The type is in the geological museum of Columbia College.

ISCHYPTERUS ELEGANS, n. sp.

Pl. VII, Fig. 2; Pl. X, Fig. 1; Pl. XIV, Figs. 1, 2.

Fishes small, length four to six inches, greatest breadth two inches; length of head one to one and a quarter inches, contained four and a half times in the entire length; body long-ovoid, elegantly arched; teeth relatively large, conical, acute; scales smooth, about twenty in each vertical row in broadest part of body, and thirty-two in a longitudinal series along the median line to the base of the triangle which extends into the upper lobe of the tail; erect scales along dorsal line anterior to dorsal fin about twenty, relatively small, first four or five unarmed; head small, pointed, depressed; fins small, weak.

This is the neatest species of the genus known to me; the curves of the outline of the body are graceful, the scaling crowded but exact. In form it most resembles *I. lineatus*, but is smaller and broader, the back is more distinctly and regularly arched, and the scales are more numerous. Another peculiar feature in the outline is the sudden contraction of the body behind the dorsal fin. The scales are brilliantly polished, and each one usually retains its position, so that the surface and outlines of the fish are well preserved. From this it may be inferred that the scales were thicker and more firmly united than in most species of the genus.

Collected at Boonton, N. J.; type specimens in the geological museum of Columbia College.

ISCHYPTERUS ALATUS, n. sp.

Pl. VIII, Figs. 1, 2.

Fishes robust, eight inches in length by two and a half inches in greatest breadth; head large, nearly one-third of entire length; fins relatively

large, rays and fulcra strong; dorsal fin set at the middle of the entire length and midway between the occiput and base of caudal.

These fishes resemble most those I have called *Ischypterus lineatus*, and they may prove to be only a well-marked variety of that species; but in this group the body is somewhat narrower, the head is larger, the fins are stronger and more conspicuous, and the dorsal is more posterior in position.

Up to the present time fishes having the characters given above have only been found at Boonton, N. J. The types are in the geological museum of Columbia College.

ISCHYPTERUS MODESTUS, n. sp.

Pl. IX, Figs. 1, 3.

Fishes four to six inches in length by one and a half to two inches in width; outline of body long-ovoid, symmetrically arched above and below anterior to dorsal and anal fins, rapidly contracted behind to half the anterior breadth; fins broad, strong, and rounded; dorsal fin exactly in middle of entire length, opposite ventrals, fulcra strong, twelve in number, rays eleven; tail relatively broad, slightly emarginate lobes nearly equal, rays fifteen; anal rounded, not reaching base of caudal, fulcra ten (?), rays seven; head relatively large, one-fourth the entire length, rounded, somewhat obtuse; scales of dorsal line eighteen, of medium size, the one immediately anterior to the dorsal fin shield-shaped, not emarginate behind; scales of sides relatively large and thick.

The fishes which have been included in this species are small, and have the outlines of the body and fins rounded so as to give a smooth and gentle aspect; the curves of the body are all graceful and flowing; the back and abdomen are uniformly arched to the dorsal and anal fins; behind these the outline contracts rapidly by concave curves until the width at the base of the tail is less than half that of the anterior portion of the body.

The fishes most nearly allied to these are those which I have included under the name *I. elegans*, and it is perhaps not certain they should be regarded as distinct. The head is, however, more obtuse and rounded, the back less highly arched, and the fins apparently broader than in that species. Also the scales are larger and thicker and those of the dorsal line stronger.

Collected at Boonton, N. J. Types in geological museum of Columbia College.

ISCHYPTERUS LENTICULARIS, n. sp.

Pl. X, Figs. 2, 3.

Fishes six to six and a half inches long by two to two and a half inches wide; general outline lenticular; body widest at the middle, sloping gently to the muzzle and tail; head pointed or obtuse, relatively large, a little less than one-quarter of the entire length; fins all small and delicate for the size of the fish; scales apparently thin, those of the dorsal line relatively small.

Among several hundred fishes obtained at Boonton, N. J., there are a number which correspond to the above description. They are relatively broad and have a nearly symmetrical lenticular outline, the tail being small and the body at its base only about one-third as wide as before the dorsal fin. The fins are all small and weak, the fulcra slender, nearly straight and closely appressed. The general form is similar to that of *I. ovatus*, but these fishes are not half the size of those to which W. C. Redfield gave that name, and the whole structure is much more delicate. In *I. ovatus* the scales of the dorsal line and sides would seem to have been very thick and strong, the fins are large, the fulcra strongly arched. The relation of these smaller ovoid fishes is rather with those to which I have given the name *I. elegans*, and here the differences may be those of age or sex. The group designated by the latter name consists of fishes which are much smaller, often not much more than half the length and breadth, the lower line of the body being nearly straight, the upper highly arched before the dorsal fin, concavely narrowed behind. Hence I have supposed that they constitute a distinct species.

Up to the present time I have seen no such fishes as those under consideration at any other locality than at Boonton. There are none such in all the collections made at Durham or Sunderland. In the first of these localities *I. micropterus* apparently takes their place, but this, though like in the small size of the fins, is distinguished by its depressed, pointed muzzle and the cuneate outline of the body, which is widest immediately behind

the head. At Sunderland, *I. tenuiceps* is the prevailing species, and, though often ovoid in outline, may always be distinguished by its humped back and huge dorsal scales. The fins are also larger than those of either of the above mentioned species.

ISCHYPTERUS LINEATUS, n. sp.

Pl. XI, Figs. 1, 2.

Fishes six to eight inches in length; outline when perfectly preserved uniformly arched above and below; head relatively large, contained about four times in entire length, broadly conical in outline; fins all large; fulcra arched; scales of dorsal line spinous and strong, but less developed than in *I. tenuiceps;* ribs and interspinous bones frequently preserved; scales on sides thick and strong, arranged in continuous rows from the head backward, so as to give a lined appearance, which has suggested the specific name.

The fishes of this group are not easily separated from some of their associates; some individuals resembling those of *I. lenticularis;* but in these latter the outline is more symmetrical, the fins smaller, the scales more delicate, particularly those of the dorsal line. On the other hand, they approach through the smaller individuals the group to which I have given the name of *I. elegans;* but these latter are smaller, the arch of the back is higher, the head more depressed and acute, the fins and scales are more delicate. Still another variety, including the narrower forms, comes nearer to *I. fultus.* On the whole, however, this group of long ovoid fishes, from two to three inches wide, are distinguishable at a glance from those which have the narrow lanceolate outlines of *I. fultus*, a fish which, though attaining the length of six to seven inches, never passes a width of an inch and a half.

The fishes to which I have given the name of *Ischypterus alatus*, and have represented on Pl. VIII, are perhaps most like those under consideration, and I hesitated long before separating them; indeed, it is probable they will be found to run into each other, so that they must be regarded as varieties of one species. By comparing the figures now given, however, it will be seen that in the fishes I have called *I. alatus* the fins are stronger, and the dorsal is placed farther forward, its anterior margin being just mid-

way between the occiput and the base of the caudal fin. In the fishes named *I. lineatus* the body is shorter and broader, the sides are more distinctly lined, and the dorsal fin is set farther back.

Found in considerable numbers at Boonton, N. J., but up to the present time not obtained from any other locality.

Type specimens in the geological museum of Columbia College.

ISCHYPTERUS MACROPTERUS W. C. R.

Pl. XII, Fig. 1.

Fishes six to eight inches in length by one and a half to two and a half inches broad, long-ovoid or fusiform in outline, symmetrically arched above and below; head large, one quarter the entire length, conical in outline; fins relatively large and strong; dorsal opposite the interval between the anal and ventrals, point of insertion nearer to the extremity of the tail than to the muzzle, fulcra fifteen, rays eight ?; caudal broad, rays and fulcra strong; anal reaching to base of caudal, fulcra fifteen, rays ?; scales relatively thick; ribs and spinous processes strong, and often distinctly showing in the fossil state.

W. C. Redfield[1] describes very briefly a species of *Ischypterus*, which he calls *Palæoniscus macropterus*, in the following words:

> ***Palæoniscus macropterus*** W. C. R.—Long-finned Palæoniscus. This species is distinguished by the longitudinal extension of the dorsal and anal fins; which thus seem to present a remote resemblance to the wings or forked tail of the common swallow. Its length is commonly from five to seven inches, and its width from one and a half to two inches.

Among the large number of fossil fishes which have been collected at Boonton, N. J., the most abundant are such as were regarded by the Messrs. Redfield as representing Agassiz's species *Ischypterus fultus*. They are generally fusiform in outline, six to eight inches in length, and all have in marked degree the strong fin-fulcra characteristic of the genus. There are, however, two groups of these fishes having about the same average size, one more slender and coming nearer to those which, sent from the Connecticut Valley, were described by Agassiz with the name of *Palæoniscus fultus;* the

[1] Short Notices of American Fossil Fishes, Am. Jour. Sci., vol. 41, 1841, p. 25.

other group is much broader, the body being sometimes two and a half inches high anterior to the dorsal fin. These were relatively flat fishes, while the others were cylindrical or fusiform. As we compare most of the members of the two groups they seem so unlike that no one would hesitate about considering them distinct species, but it is also true that there are intermediate forms, which serve to connect these groups, and which are apparently as near to one as to the other. Hence it is not easy to define accurately either of the two species which W. C. Redfield has founded upon them. In most cases, however, there need be no doubt, the fusiform and slender fish standing for *I. fultus*, the broader one for *I. macropterus*. In my notes on *Ischypterus fultus* I have further discussed this question, and have shown how difficult it is to identify the species, which have been described very briefly from imperfect material, and where the type specimens have been lost sight of.

Another reason why we may suspect that the fishes combined by Agassiz and subsequently by Redfield under the name of *I. fultus* should be referred to two species, is found in their distribution. As remarked elsewhere, the individuals figured by Agassiz and taken as the types of his species *fultus*, are so imperfect that they cannot certainly be identified with any of the Triassic fishes obtained from the Connecticut Valley or from New Jersey. I have even suspected that they were only mutilated specimens of the most common speices, *I. tenuiceps*, found at Sunderland, where Agassiz's fishes were obtained; but occasionally a narrow, fusiform, and smaller fish is met with at Sunderland and Turner's Falls, which may be the same with those figured by Agassiz. Whether this is identical with any of the fishes found in New Jersey is yet uncertain, because the material we now have for comparison is inadequate; but if identical with either of the New Jersey forms it is with the narrower one, which was adopted by W. C. Redfield as the representative of the species *I. fultus*. Up to the present time none of the broader fishes which I have taken as representing Redfield's species or variety, *I. macropterus*, have been found the Connecticut Valley; a fact which justifies the inference that these in closely allied forms are specifically distinct.

Ischypterus Braunii, n. sp.

Pl. XII, Fig. 3; Pl. XIII, Figs. 1, 2, 2*a*.

Fishes three to five inches in length by one to one and a half inches broad; outline long-elliptical; body compressed; head relatively large, contained three to three and a half times in total length; teeth large, pointed, acute; cranial bones granulated; operculum semicircular, large; preoperculum long-elliptical, having much the form of the operculum, but very much smaller; fins small, with delicate fulcra and rays; dorsal and anal placed far back, dorsal midway between occiput and extremity of tail, very long from front to rear, fulcra small, rays ten; anal reaching back to or beyond base of caudal, fulcra eight (?), rays five; jointed rays of caudal fin fifteen; scales rhomboidal or square, more uniform in size than any other species known, number along lateral line thirty-three, in vertical rows sixteen; scales of dorsal line rounded before, pointed or short-spined behind.

This species is of peculiar interest as coming from the base of the Triassic rocks of New Jersey, from a horizon probably several thousand feet lower than that of the Boonton specimens, which are from near the top of the series. It may be distinguished from all other known species by the uniformity in the size of the scales and by the posterior position of the dorsal fin. The armature of the dorsal line is also less strong and conspicuous than in most of the species of the genus; in this respect it is intermediate between the strongly spined species of *Ischypterus*, such as *I. tenuiceps* and those which have been grouped in the genus *Acentrophorus* by Dr. Traquair, of which we have an example in *A. chicopensis*, described in this memoir. In that fish all of the median scales of the dorsal line anterior to the dorsal fin are unarmed.

The only locality from which fishes of the present species have been obtained is Weehawken, N. J. Here, beneath the trap of the Palisades, is a stratum of highly metamorphosed slate which was once a bituminous shale, but which has been baked by the effusion of the great mass of molten matter above it; the fishes are found in this slate. In some layers it also

contains great numbers of bivalve crustaceans (*Estheria*), which would seem to indicate that it was deposited in brackish water. But little excavation has been made in this stratum, and it is probable that it will hereafter yield other things new to our Triassic fauna

A description of this locality and of the fossils found there was published by L. P. Gratacap.[1] A wood-cut figure of a large specimen of fish found there is given, and it is regarded as identical with *Palœoniscus latus* of Redfield. Through the courtesy of Mr. Gratacap I have examined the original of his illustration, and I have been permitted to make a drawing of it, which is now published (Fig. 2). I found it essentially like a large number of fishes from Weehawken which are in my hands, except that it is larger and broader than any other specimen I have seen. All the fishes from this locality have the dorsal and anal fins set far back, the anal reaching to or beyond the base of the caudal. This would serve to distinguish them from *I. latus*, but they also differ from that species in the greater uniformity in the size of the scales In most species of *Ischypterus* four rows of scales on either side of the line of dorsal spines are nearly square; the next eight rows are higher than long; then follow seven rows of smaller scales to the median line of the abdomen. In these fishes, however, the scales on the side are not conspicuously larger than the others, and there is also less difference in their size, going from front to rear. Hence I must conclude that they belong to a distinct species from *Ischypterus latus*, which also occurs much higher in the Triassic series. In Mr. Gratacap's figure the number of scales in the vertical rows of the side is represented as twenty-three; a number which I have found equaled in only one species of the genus, *I. ovatus*, in which it is twenty-four. The specimen does not permit the scales in the widest part to be counted, but immediately anterior to the dorsal and anal fins the number is apparently sixteen; this renders it probable that the number in the anterior rows may reach nineteen, a number which may be considered as normal for the genus.

The posterior position of the dorsal fin, the uniformity in the size of the scales, and the unarmed or short-spined character of those of the dorsal line clearly mark this species as distinct from any other known.

[1] Am. Naturalist, vol. 20, 1886, pp. 243–246.

ISCHYPTERUS PARVUS W. C. R. (MS).

Pl. XIII, Fig. 4.

In the manuscript report of J. H. Redfield, now in my hands, I find a description of a small species of *Ischypterus* to which he gives the above name, crediting it to W. C Redfield. He also refers to the figures given by Prof. Edward Hitchcock[1] as illustrating the species. His description is as follows:

> Fish small and fusiform; head small—less than one-quarter length of fish; scales minute concentrically striate, pectorals rather small, rays delicate; ventrals very small; dorsal small and triangular, with anterior raylets stout and few in number; anal very small; tail forked, lobes rather obtuse; length three inches, breadth three-quarters of an inch.
>
> Occurs at Sunderland, Mass., Boonton, N. J., and perhaps at Westfield, Conn.
>
> This species is rare. Very few perfect individuals have been found. Its small size and the delicate character of its scales and fins will at once distinguish it.

The above description is so brief and general that in the absence of type specimens it is difficult, if not impossible, to identify the species. The figures in the Geology of Massachusetts, to which Mr. Redfield refers, are evidently drawn from very imperfectly preserved fishes, of which little more can be said than that they belong to the genus *Ischypterus*. They are, however, quite distinct from the little fishes found at Durham to which I have given the name *I. minutus*, being narrower and more fusiform and with much smaller dorsal fins. A little fish found at Sunderland, much more like those figured by Hitchcock, is represented on Plate XVIII, Fig. 4. It is fairly well preserved, and we can see by its fusiform body and small dorsal scales that it is not the young of *I. tenuiceps*. There can be little doubt, therefore, that it represents the species figured by Hitchcock and cited by Redfield as representing his *I. parvus*. The figure now given may therefore be taken as the first truthful illustration of that species. Whether it is distinct from any other described remains to be shown by further investigation. At Durham and Sunderland fusiform fishes of the genus *Ischypterus* considerably larger than this or that figured by Hitchcock occur, though rarely, and not often in good preservation. These have the general

[1] Geol. Mass., quarto ed., vol. 2, pl. XXIX, fig. 3, and in atlas accompanying octavo ed., pl. XIV, fig. 44.

aspects and proportions of the much smaller fish now figured, and it is possible they are only older individuals of the same species. Of this, however, we have no positive proof. The larger fishes referred to were considered by W. C. Redfield as belonging to the species *I. fultus*, and that is possible; but judging from the material I have seen I should say the fishes of the Connecticut Valley were more delicate in structure, with smaller and weaker fins, and that they will probably prove to be distinct.

ISCHYPTERUS LATUS J. H. R.

Pl. XIII, Fig. 3.

Palæoniscus latus J. H. R., Annals New York Lyceum Nat. Hist., vol. 4, Pl. II, without description.

Palæoniscus latus J. H. R., Am. Jour., Sci., vol. 41, 1841, p. 25.

The figure given by Mr. J. H. Redfield in the Annals of the Lyceum lacks the head and does not fully show the tail nor the fins. No description accompanies the plate in the article referred to above; the only mention of the species in the Journal of Science is exceedingly brief, and reads as follows:

Palæoniscus latus J. H. Redfield—Broad Palæoniscus. The common length of this species is from four to five inches, and its width is from one and a half to two and a quarter inches. It is figured in the Annals of the New York Lyceum of Natural History, vol. 4.

Found at Westfield, Middlefield, and Durham, Conn., and Boonton, N. J.

In the manuscript catalogue of the fossil fishes of the United States, read before the Association of American Geologists and Naturalists by J. H. Redfield, I find the following description of *Palæoniscus latus*.

Fish ovate, fusiform, head obtuse, rather large, between one-third and one-quarter the whole length of the fish; scales small, those of the anterior portion of the body much deeper than long, concentrically striate, especially on the posterior edge; pectoral fins small and delicate; ventrals small; dorsal rather large, with anterior raylets very long, stout, and numerous; anal moderate, anterior raylets strong, tail forked, lobes rather obtuse, anterior raylets small; length four to five inches, breadth one and a half to two inches.

Occurs at Sunderland, Mass.; Middletown, Conn.; Pompton and Boonton, N. J.

The dorsal and anal fins of *P. latus* are far less elongated than in the other species, though they still preserve the strong armature peculiar to the American species of

Palæoniscus. **The comparative breadth of this species with the smallness of its scales will also readily distinguish it from its American congeners. The scales of the anterior portion of the body are deeper in proportion to their length than in any other species unless in *P. ovatus*.**

The figure given of this species by J. H. Redfield was taken from a specimen which has unfortunately been lost. I have not been able to find in the Redfield collection the original of this figure; it probably belonged to the New York Lyceum of Natural History, and was burned with the rest of its collections. The lack of it has made the identification of the species difficult. There are, however, no small, short, and broad fishes found at the localities enumerated by Mr. Redfield that agree at all well with his figure and description.

At Sunderland, Mass., and Plainfield, N. J., we have obtained a few small ovoid fishes which correspond better than any others with the definition of *I. latus*. These fishes have about the dimensions assigned to this species by J. H. Redfield, viz, a length of four to five inches and a width of one and a half; the head is relatively small and pointed, the scales of the dorsal line are prominent, and the broad shield-shaped scale which covers the base of the dorsal fin is relatively very large—as large, indeed, as in any of the large species of the genus—and is notched behind where it touches the first of the fulcra. The fins are all small and weak, the body immediately anterior to the caudal fin is narrowed to about one-third of the breadth between the head and dorsal, the scales are relatively small and crowded, eighteen in a vertical row between the median lines of back and abdomen in the broadest part of the fish. Of these, the six lower are small, square, and of nearly uniform size; the seventh row is the beginning of a series consisting of eight, which are higher than long, the middle ones near the head being just twice as high as broad; above these higher scales are four rows of smaller square ones, of which the uppermost is excavated to fit the rounded base of the great spined scale which stands at the head of the row.

These little fishes I have supposed might represent Mr. Redfield's species, but I have found none at Boonton or Durham which I could associate with them. At Boonton a somewhat similar species (*I. elegans*) is not uncommon, but that is larger, has smaller dorsal scales, and a more arched back.

ISCHYPTERUS MINUTUS, n. sp.

Pl. XIII, Figs. 5, 5*a*.

Fishes three inches in length by one inch broad; long-ovoid in outline; body widest at base of dorsal fin; head pointed, one-quarter the entire length; dorsal fin located at about the center of the body, relatively large and broad; anal fin just reaching to base of caudal; tail narrow; caudal fin, like all the others, delicate in structure.

The little fishes upon which the above description is based have been found only at Durham, Conn. They differ from the other small species of the genus found elsewhere by their broader, more ovoid outline, the large size and breadth of the dorsal fin, and the general delicacy of structure.

It is quite possible that we have here the young of some species of *Ischypterus* of which the mature form has been described under another name, but there is no fish found in the locality where these occur with which the resemblance is so close as to indicate this, and no connecting links have been found between these little fishes and those of larger size. Their structure was evidently very delicate, and they are so imperfectly preserved that a full description and satisfactory comparisons can not be made from any specimens yet obtained. Till more material further illuminating the subject shall be procured we may consider the individuals of this species as distinguished by their small size, ovoid form, delicate structure, and especially by the relatively great size and breadth of the dorsal fin.

The small size is in itself, perhaps, a sufficient reason for the delicate structure, which permitted the destruction of most parts; but it will be noticed that in both the specimens now figured the body is unusually wide opposite the dorsal fin, and this fin is relatively larger and broader than in any other known species of the genus. Possibly this is simply the result of immaturity, as the fins are abnormally large in many young fishes. The great breadth of the dorsal fin may, however, prove a constant character, and thus serve as a means of distinguishing the species. Small fishes occur at Boonton and Sunderland, but they are usually so badly preserved, that little can be said of their specific relations. Only at Durham do we find

the details of structure retained, and all the small fishes of the genera *Catopterus* and *Ischypterus* which I have thought worthy to be figured have been obtained there.

It is somewhat remarkable that among the thousands of presumably mature individuals of all the six genera yet found in our Triassic rocks the young are so generally absent. Some difference in size is perceptible among those which we suppose to represent the twenty-eight known species, but if young and old were in the habit of associating together we ought to have graded sizes of many of the species. From the facts that we do not find them and that the variation in size among those which we are able to distinguish by certain definite characteristics is limited, we must infer that the young of all or most of these species associated together in different localities from those where the mature individuals are now found. Probably some such nurseries of the Triassic fishes will yet be discovered and will help the paleontologist of the future to discriminate between the species, but we must conclude that in the material now before us we have only mature or submature fishes, and this gives a probability to the distinctions we now make. Where we find twenty, fifty, or one hundred fishes which present common characters in size, outline, strength, shape of fins, etc., we may fairly conclude that these represent one species. Like all similar work, however, this must be considered as only provisional and liable to modification by the accumulation of more and better material.

ISCHYPTERUS GIGAS, n. sp.

Pl. XIV, Fig. 3.

Among the fish remains which were the fruit of many weeks of quarrying at Boonton a few fragments were obtained which belong to a species of *Ischypterus* much larger than any hitherto described. Unfortunately, the importance of these specimens was not appreciated by the quarrymen, and they did not take pains to preserve all the material which they brought to light. The remains of two individuals were found, both unfortunately much macerated and dismembered, the tails and posterior portions of the body, the most resistant parts, alone being well preserved. The heads and

middle portions of the body were a mass of scales and bones apparently representing the place and area of the abdomen, shoulders, and head, but two much confused to admit of accurate description or representation. The length of the fish must have been eighteen to twenty inches and the breadth of the body at the widest part at least six inches. At the narrowest point, immediately anterior to the base of the caudal fin it is quite two inches wide; the tail when fully expanded must have been five or six inches broad. It consisted, apparently, of fifteen closely jointed rays, some of which are one-quarter of an inch in width; the fulcra are numerous above, still more so below; the anal fin was about three inches long, having at least sixteen fulcra and seven rays; the scales half an inch or more in diameter, thick, enamel covered, and shining. The general aspect of the fish is that of *Lepidotus*, as it is much larger and coarser than most species of *Ischypterus*. The tail, however, is considerably more heterocercal than in any species of *Lepidotus*, and in fact in structure is precisely like that of *Ischypterus*. The dorsal line is very imperfectly shown in my specimens, and it is impossible to determine from them whether a row of spine-like scales extended from the head to the dorsal fin. This would be conclusive as to the relationship of this fish to *Ischypterus*, and doubtless that evidence will be forthcoming.

Genus CATOPTERUS J. H. R.

Tile-scaled ganoids of medium size, body fusiform or long-ovoid in outline; head relatively small, obtuse or acute, all head bones highly ornamented; cranium opercula, maxillaries, and mandibles covered with tubercles of enamel; clavicles bearing parallel or interrupted raised lines; teeth numerous, conical, acute on premaxillaries, maxillaries, and mandibles; fins broadly or narrowly triangular, acute, all bearing numerous closely-set, rod-like fulcra along the anterior margins; rays many-jointed, enameled, and polished; dorsal fin placed far back on the body, generally opposite the middle of the anal; caudal fin deeply and gracefully forked; extremity of body obliquely rounded and extended a short distance into the upper lobe of the caudal fin; anal fin reaching nearly to base of caudal; ventrals midway between anal and pectorals; scales rhomboidal on the sides, toward

the head quadrate, often toothed, near the tail long lozenge-shaped, acute. Along the middle line of the back runs a row of somewhat larger ovoid, or polygonal scales of peculiar form. The surface of most of the scales is smooth and polished, but in some species those on the sides near the head are marked with oblique raised lines, and in one species the surface is occupied by lines parallel with the margin and converging to the posterior point.

The most striking peculiarity of this genus is the posterior position of the dorsal fin, a character which suggested the name given it by J. H. Redfield.

The species of *Catopterus* are among the most beautiful of fossil fishes; the outline is graceful, the head bones are crowded with ornamentation, the scales highly polished, often serrate or toothed on the posterior margin, and decorated with parallel or concentric raised lines. The fins are long, graceful, and flowing; the pectorals are falcate and acute, the first rays very strong, and thickly set with short fulcra, which give it a serrate appearance The margins of the other fins are decorated in the same way, so that the genus may be recognized by even a fragment of a fin. The fin rays are very numerous and frequently articulated, the joints flattened and highly polished, so that in the fossil state the form and structure are often beautifully preserved and never fail to excite admiration in the observer.

No species of *Catopterus* has yet been found in the Mesozoic rocks of the Old World, or, at least, no fossil fish has yet been identified as such In eastern America, however, during the latter part of the Triassic age, two or three species were exceedingly numerous in the lakes and estuaries of the Atlantic coast. In New Jersey and the Connecticut Valley the species of *Catopterus* are fewer than of *Ischypterus*, and the number of individuals is on the whole less, but in some localities the two genera are about equally represented. They may be distinguished at a glance, even when minor differences are not shown, by the position of the dorsal fin. In *Ischypterus* this is always anterior to the anal, while in *Catopterus* it is either opposite or posterior.

Since the above description was written I have received from S. W. Loper, of Durham, Conn., some specimens, which enable me to add some-

thing to the generic description, as they show better than any before known the under and upper sides of the head. From these it appears, first, that on the under side of the body the scales extend in a V-shaped point considerably forward of the pectoral fins, the extreme angle being under the center of the head. Secondly, the apex of the arch formed by the mandibles is occupied by a median jugular plate similar to that of *Amia;* its surface is covered with coarse, rounded, or elongated tubercles, and its sides are notched to receive the conical extremities of the interclavicles (?) by which it is bordered. These are covered with polished raised lines with a radiated arrangement at the extremity; they are often broken into tubercles of enamel. Thirdly, the mandibles are narrow and slender and, like the other bones of the head, coarsely granulated. Fourthly, the under side of the pectoral fins shows about ten rays which, simple at base, soon divide into polished rods articulated only toward their extremities; in this respect showing a structure very different from that of the upper surface, in which the articulations are short and numerous, apparently metamorphosed scales; a character exhibited throughout the unpaired dorsal, caudal, and anal fins.

The bones of the sides and top of the head are not quite as distinctly shown, but the following points of structure can apparently be made out: The cranial bones are all rather coarsely tuberculated; they consist of a pair of large polygonal frontals, which are notched on the anterior lower border for the eye orbit; the ethmoid is pentagonal, wedge-shaped posteriorly, the point interposed between the diverging lines of the frontals; the sides are straight, slightly inclined toward each other forward, the anterior margin apparently joining the premaxillaries, which are united to form a transversely oval bone bristling with teeth—the extremity of the muzzle. The posterior angles of the frontals are cut to receive small oblong or ovoid parietals. The middle line of the head terminates behind by a triangular supraoccipital, of which the rounded base fits into a sinus in the frontals. On either side of the supraoccipital are small, polygonal post temporals, of which the posterior edge is joined by the scales of the back. The maxillaries are spatulate, broadly rounded or truncated behind and anteriorly fitted to the premaxillary. The orbit is formed by a bony ring, but the number of pieces composing it is not shown.

The operculum is semilunar, anterior margin slightly concave. It apparently consists of two parts, which may be operculum and interoperculum, but this is not plainly shown. Joining the mandible behind seems to be a small, oblong quadrate, but this is also too obscure to be insisted upon.

All the specimens which show the structure of the head fairly well belong to *Catopterus Redfieldi.* In these the first rows of scales next the head and in the gular triangle are ornamented with tubercles or ridges, and their posterior margins are notched or toothed. Like the joints of the fin rays these are brilliantly polished, and confirm what has been said in regard to the great beauty of the external decoration of this elegant fish.

CATOPTERUS REDFIELDI Egerton.

Pl. XV, Figs. 1, 2, 3.

Among the Triassic fishes taken to England by Sir Charles Lyell and examined by Sir Philip Egerton were (1) three species of *Ischypterus;* (2) representatives of *Catopterus gracilis* J. H. R; (3) *Catopterus Redfieldi,* "a broader fish than the preceding, and with scales not so long in proportion to their depth."[1] This is all the description we have of this species; but as there are found at Durham, Conn., many individuals of a large and broad species of *Catopterus*, and one to which the name *gracilis* is certainly inapplicable, I have thought it probable that this was the fish referred to by Sir Philip Egerton, and I take pleasure in accepting his name, and by figures and more complete descriptions securing to the founder of the genus the dedication of its finest species. This may be characterized as follows: Fish of large size, ten inches in length by three in breadth; long-ovoid in outline, broadest between ventral and pectoral fins; head small, pointed, about one-sixth of the entire length, or one and one-half inches long and deep; bones of the head all thickly set with enameled tubercles; clavicles ornamented with raised lines and elongated tubercles of enamel; dorsal fin opposite middle of anal; caudal fin forked, though less deeply than in some other species; anal fin broad, not reaching the base of caudal; ventrals midway between anals and pectorals; scales on sides near head oblong

[1] Quart. Jour. Geol. Soc. London, vol. 3, 1847, p. 278.

or quadrate, sometimes twice as high as long, surface partially covered with raised lines which project to form teeth on the posterior margin. In the middle of the body the scales are longer than high, plain or faintly striated, and bearing one or more posterior teeth; scales near tail rhomboidal, smooth; scales of median line of back transversely oval or somewhat polygonal, faintly striated; teeth numerous on premaxillaries, maxillaries, and mandibles, from one-eighth to one-quarter of an inch long, conical, subacute. The average size of the fish of this species may be said to be nine inches in length by three in breadth. The general form and proportions were similar to those of our shad and the outlines were equally elegant. As we always find the fishes of this species lying on the side, we may infer that they were laterally compressed, the vertical diameter being greater than the transverse.

The specimens for which Sir Philip Egerton suggested the name now given were from Durham, Conn., and this seems to be the special home of the species, though it has apparently been found at other localities in the Connecticut Valley and in New Jersey. Fully one-half of all the fishes obtained by Mr. Loper at Durham belong to this species, and he has furnished me with a large number of beautifully preserved specimens.

As in all the species of the genus the head seems to have been largely cartilaginous, and as a consequence is often defective or distorted in the fossils. Occasionally, however, as in the specimen represented in Fig. 1, on Plate XV, the outline of the head is accurately shown as well as the position of the eye and the form of several of the head bones. But even here they are somewhat confused, and it is difficult to compare bone by bone the structure of the head with that of the palæoniscoid fishes of the Carboniferous, with which the relationship has been supposed to be close. So far as we can judge from the specimens before us branchiostegals are wanting, the operculum is nearly vertical, and the eye surrounded by a bony ring composed of two pieces. Unfortunately the head bones are not only generally displaced, but they are covered with a coating which obscures the sutures, the matrix clinging to the granulated surfaces of the head bones much more closely than to the polished scales.

CATOPTERUS GRACILIS J. H. R.

Pl. XVI, Figs. 1, 2, 3.

Catopterus gracilis J. H. R. (Am. Jour. Sci., vol. 41, 1841, p. 27) Fish elongated, fusiform; covered with rhomboidal scales of medium size. Head rather small, one-fifth of the whole length, and in well preserved individuals presents a finely granulated surface. Operculum lunate, arched; teeth small, obtuse, in numerous rows; back nearly straight, slightly arched, lateral line nearly parallel with back. All the fins, including the caudal, have a series of very short and close raylets beginning at a point just anterior to the fin and extending from the first or anterior ray to its extremity, giving a serrated appearance to the anterior border of the fin. In the dorsal, anal, and caudal fins these raylets are preceded by imbricated, pointed scales, which seem gradually to pass into raylets; the pectoral fin is long and narrow, inserted very near the operculum; the first, second, or third rays very strong and conspicuous, the remainder more slender; all the rays except perhaps the first are articulated or subdivided toward their extremities; number of primary rays ten to twelve, anterior raylets about twenty. Ventral fins small, inserted midway between the pectoral and anal, rather near the pectoral. The rays are all slender, about eight in number, anal fin large, midway between ventral fin and tail, and occupies about one-fourth of the distance between them; the rays are twenty-five to thirty in number, very slender and filiform and much articulated; dorsal fin small and triangular, situated opposite the posterior part of the anal; rays ten to twelve, decreasing in size from the first; tail forked, slightly heterocercal; the scales of the body extending to about one-third of the upper lobe; lobes long and acute; caudal rays thirty to forty, finely articulated and subdivided. The scales of the anterior part of the body are much broader than those of the posterior, and in old individuals are undulate and subserrate on the posterior margins. The scales become more and more rhombic and decrease in size as they approach the tail; the scales of the dorsal ridges are of an irregular polygonal shape, presenting a triangular form posteriorly, and are much more imbricated than those of the sides. One or two very large scales are found upon the ventral ridge posterior to the anal fin. There are usually fifty-two to fifty-five rows of scales in length and fifteen to twenty in breadth; length of fish ten inches. Found at Middletown, Durham, and Southbury, Conn., and Boonton, N. J.

The above is a description of *Catopterus gracilis* contained in the manuscript copy of the Report on the Fossil Fishes of the United States, read to the Association of American Geologists and Naturalists at New Haven, Conn., in 1845, by J. H. Redfield, and kindly communicated to me by him.

A briefer and earlier description of the genus and species, with a figure of *C. gracilis*, was published by J. H. Redfield in volume 4, page 37, of the Annals of the New York Lyceum of Natural History. The type specimen was then in possession of the Yale Natural History Society, and is now in

the cabinet of Yale College. Unfortunately it is vertically crushed and narrowed, and gives a very imperfect idea of the species to which it belongs. After examining the specimen I am convinced that it should be associated with the broad form, for which the name *C. Redfieldi* was suggested by Sir Philip Egerton. That fish in its normal condition has nearly the outline of the shad, and with a length of ten inches has frequently a breadth of three; the name *Catopterus gracilis* is therefore inappropriate, and conveys a false impression. If the specimen figured were accepted as the type it would be better to consider it a synonym of *C. Redfieldi* and abandon the name *C. gracilis*. But there is a species of *Catopterus* which is much more slender than *C. Redfieldi*, and of this numerous specimens were in the hands of the Messrs. Redfield, and doubtless influenced them in selecting the specific name *gracilis*. It is certain that specimens of this fish served as a basis, in part at least, for J. H. Redfield's description, and it is even doubtful whether any good specimen of *C. Redfieldi* was ever examined by either W. C. or J. H. Redfield. They have mostly been procured from Durham, Conn., by Mr. S. W. Loper, in the last ten years. From these facts it has seemed to me less liable to produce confusion and to do more complete justice to Messrs. Redfield to retain the name *gracilis* for the more slender fish, to which the description of J. H. Redfield is not inappropriate, while it is not applicable to the broader form to which the specific name *Redfieldi* has been given.

I will only add to the description of J. H. Redfield that *Catopterus gracilis* is always fusiform, often quite slender, the head never more than one-fifth of the entire length, the fins relatively long and narrow, the body widest at the ventrals, where it is sometimes, though rarely, an inch and a half in width, and behind the dorsal often not much more than half an inch wide; the scales are quadrate near the head, oblong in the middle, and rhomboid at the posterior extremity of the body. They are sometimes finely serrate on the posterior margins, never deeply toothed as in *C. Redfieldi*, and the surface in all the specimens I have seen is essentially plain. On Pl. XVI, Fig. 1, is represented an entire fish of this species, and one of the broader forms, while Fig. 3 shows the posterior half of the body of one of the more slender individuals. The difference of form between this and

the preceding species will be seen by comparing the latter figure with that of a corresponding portion of the body of *C. Redfieldi* given on Pl. XV, Fig. 3.

CATOPTERUS MINOR, n. sp.

Pl. XVII, Figs. 1–4.

Fishes robust, fusiform, five to six inches in length by one and a half inches in diameter at widest part, which is immediately behind the pectoral fins; head depressed, conical, pointed, all head bones covered with coarse granulations of enamel; clavicles marked with strong longitudinal plications; fins triangular or falcate, sharp-pointed; caudal deeply forked, lobes gracefully arched, acute; dorsal and anal fins opposite; radial formula as follows: Pectorals—fulcra twenty-seven, rays six; ventrals—fulcra eighteen, rays five; anal—fulcra twenty-four, rays twenty long and three shorter on anterior margin; dorsal—fulcra three, rays fifteen; caudal—rays thirty long, three shorter above and below, thirty-six in all; lower lobe—fulcra thirty, with three large fulcral scales at base; upper lobe—fulcra eighteen, with three fulcral scales, which are succeeded forward by four large peltate scales on dorsal line, reaching half way to base of dorsal fin; scales quadrangular, nearly uniform in size; on the lateral line forty-two, which are marked by mucous tubes; about twenty-four in the vertical rows on the side near the head; those of the median line ovoid or polygonal; surface of all the scales on the anterior portion of the body ornamented with raised lines; on the nape and abdomen part of the scales carry one or two raised lines parallel with the margin and converging to the posterior point; on the side near the head all the scales are obliquely traversed by raised and often beaded lines, which terminate in acute denticulations of the posterior margin. From Durham, Conn., I have obtained, through Mr. Loper, quite a number of small specimens of *Catopterus*, which are of nearly uniform size—about five inches in length by one and a quarter in width—all lying partly upon the abdomen and showing the line of median scales upon the back. This proves that the body was round, or perhaps somewhat flattened vertically; the head is small, depressed, pointed; the scales of the posterior portion of the body highly polished; those of the anterior ornamented with raised lines and having the posterior

margins coarsely denticulate; the fins are of moderate size, very graceful in their outlines and beautifully constructed and preserved. On the whole, these are the handsomest fossil fishes of which I have any knowledge.

I have been somewhat in doubt whether they may not be regarded as the young of *C. Redfieldi*, with which they are associated and which they in some points resemble, but they present some distinct characters which they have in common among themselves, such as the pointed head, the round and vertically flattened body, the ornamented scales varying comparatively little in size, and the opposite position of the anal and dorsal fins. These characters have seemed to me sufficient to make this little group of fishes the representatives of a distinct species. The relationship of these fishes to that which I have called *Catopterus ornatus* is close; the size, form, position, and other features of the body are the same, the only difference being the peculiar ornamentation which covers most of the scales of *C. ornatus*, and is only faintly indicated in a very few scales of some individuals of *C. minor*. The radiating lines which mark the side scales in the present species are wanting or but faintly indicated in *C. ornatus*, but we have some traces of them in the much larger fishes which I have supposed to represent *C. Redfieldi*.

The theory that these fishes constitute a distinct species of *Catopterus* is confirmed by the fact that, so far as at present known, they are found at no other locality than Durham, Conn., although the larger species of the genus are abundant at Boonton, and are sometimes met with at Sunderland.

CATOPTERUS ORNATUS, n. sp.

Pl. XVIII, Figs. 3, 3*a*, 3*b*.

Fishes fusiform, five inches long by one and a quarter inches wide at the broadest part; head bones unknown; fins all delicate; anal opposite dorsal; scales rhomboidal or elliptical, of nearly uniform size, relatively large, external surface ornamented by raised lines parallel with the border and terminating in the posterior point or angle; along the dorsal median line is a row of ovoid scales somewhat larger than the others, marked by the usual raised lines parallel with the margin, and in addition a single raised line, sometimes beaded, which passes from the center of the scale to the posterior point. On the sides near the head the scales, which all show

more or less of the concentric lines, are also faintly marked with radiating, beaded lines terminating in sharp teeth at the posterior border.

Only a single specimen of this little fish has yet been found. It has the form and size of *Catopterus minor*, but differs from that and all other species known, in the peculiar and pronounced ornamentation of the scales. Most of these are decorated with strong raised lines parallel with the margins and running to the posterior point, which is often somewhat prolonged. On the sides near the head this ornamentation is joined to or superseded by the radiating raised beaded lines terminating in teeth, often though not always seen in *Catopterus Redfieldi* and *Catopterus minor*. The body must have been round or somewhat flattened vertically, since it lies on the abdomen with the middle line of the back uppermost, the position generally assumed by the fishes which I have designated by the name of *C. minor*. The general aspect of these fishes is so similar, that I have been inclined to consider them as varieties of the same species, but the ornamentation of the scales in *C. ornatus* is so marked, that I do not feel authorized to unite them without better evidence than I now possess.

The ornamentation described above is on the same plan with that of the scales of *Cœlacanthus elegans* from the Coal Measures, but the number of raised and converging lines is less in the Triassic fish.

Figs. 3*a* and 3*b* represent the scales enlarged to show the ornamentation, the former the ovate scales of the dorsal line, the latter the rhomboidal scales of the sides.

CATOPTERUS ANGUILLIFORMIS W. C. R.

Pl. XVIII, Fig. 5.

W. C. Redfield describes a species of *Catopterus* in the following words:[1]

Catopterus anguilliformis W. C. R. (Eel shaped Catopterus).—This remarkable species, as hitherto found, is from seven to nearly ten inches in length; width, half to three-fourths of an inch. It has a finely-forked and extended caudal fin of delicate structure; a well-extended dorsal; and all the fins are fringed with the fine raylets which pertain to this genus. The impressions of the fins are usually but faintly visible, owing, probably, to their delicate structure. The scales are equally indistinct, and the impression of the head is seldom visible.

Found at Westfield and Middletown, Conn.; Boonton, N. J.; and, as I have been informed, at Sunderland, Mass.

[1] Amer. Jour. Sci., vol. 41, 1841, p. 27.

In the collection of fossil fishes left by W. C. Redfield, and among hundreds of specimens I have examined from Boonton, Durham, Sunderland, and elsewhere, I have seen but two which correspond with this description. These are from Durham, and are contained in a shale that is quite metamorphosed, and in which the impressions of the fossils are indistinct. They are very defective in details of structure, but it is hardly possible to avoid the conclusion that they represent a fish different from any other known. One of these is represented on Pl. XVIII, Fig. 5; the other is larger, though scarcely wider, and the outline is less complete.

It would be somewhat surprising if it should prove true that in the same locality lived two species of the same genus differing in form as much as these slender eel-like fishes differ from *Catopterus Redfieldi*, which, when mature, was relatively as broad as a shad. It is therefore quite possible that when better specimens of the slender fish shall be found they will present points of structure which will require reference to a new genus. So far as can be observed, however, they exhibit the characters of *Catopterus;* the tail is deeply forked, and the caudal, like the pectorals, is bordered by the fine fulcra so characteristic of that genus; so that, till conflicting evidence is found, we must follow W. C. Redfield in the name he has given. The absence of all details of structure in these fossil fishes is proof of great delicacy of organization, such as we find in the young of most fishes, but the great length of these specimens forbids the inference that they are young fishes, since no traces of larger individuals with anything like the same proportions have been discovered.

Catopterus parvulus W. C. R.

Pl. XVI, Figs. 4, 5.

The description given of this species by Mr. Redfield will be found in the article[1] so frequently cited on the preceding pages. It reads as follows:

Catopterus parvulus: W. C. R. (Little Catopterus).—This small and delicate fossil is but obscurely developed in the few specimens which have been obtained. The extremely fine spread caudal and other fins, with their slender frontal raylets, serve to

[1] Am. Jour. Sci., vol. 41, 1841.

mark it as a member of the genus, although these raylets are fewer in number and of greater and more unequal length than in the other species. In the few specimens obtained the caudal extremity is commonly found in a bent or half-twisted position.

Found at Middlefield, Conn., Sunderland, Mass., and Boonton, N. J.

In our excavations at Boonton, where we obtained several hundred fishes in better or worse condition, a few delicate, imperfect, and usually distorted specimens were found which correspond fairly well with the above description, and yet it has seemed to me that they are probably the young of the larger species of *Catopterus*; if not, the species can only be satisfactorily defined from material more perfect than any I have yet seen.

These little fishes are generally from two and a half to four inches in length and very imperfectly preserved; that is, the scales are scarcely visible and all details of head structure are wanting. The fins, especially the caudal, are sometimes fairly well shown, and consist of numerous extremely fine parallel rays bordered by fulcra of corresponding delicacy. These prove that they belong to the genus *Catopterus*, but their minute size and their delicacy of structure are signs of immaturity, and it is therefore impossible to affirm that they constitute a distinct species. It may be said, however, that with these little fishes somewhat larger ones are found which exhibit nearly equal delicacy of structure. They are from four to six inches in length, with a maximum width of perhaps an inch near the head. The fins are sometimes well shown, but the scales are almost invisible. Something of their indistinctness may be due to decomposition or to imperfect fossilization, but the fin rays are much more slender than in the smaller individuals of *Catopterus* found at Durham, which I have designated by the name *Catopterus minor*. Hence I must conclude that they are not specifically identical with these. For the present it may be perhaps as well to let these small, delicate, and imperfectly preserved specimens of *Catopterus* stand for Redfield's species *C. parvulus*, but it is quite possible they will prove to be the young of *C. gracilis*.

Genus DICTYOPYGE Egerton.

Small heterocercal ganoids; body fusiform; head small, conical, one-fifth the entire length; muzzle rounded, obtuse; opercula large, semicircu-

lar; clavicles coarsely plaited; bones of the head all granulated; scales rhomboidal, smooth, those of the lateral line strongly marked, oblong, somewhat rounded above and below, emarginate behind, showing conspicuous mucous pores or tubes; scales of the under side of the body very numerous, narrow, elongated longitudinally; pectoral and ventral fins small; dorsal fin opposite to or a little in advance of the anal; caudal fin forked; anal fin broad, rounded, consisting of twenty-two long and two short rays, of which the central ones are broadest and are supported by strong interspinous bones; anterior rays of all the fins set with short, oblique, obtuse, polished fulcra. At the base of the caudal fin, above and below, these are succeeded by large, ovate, pointed, fulcral scales, which reach forward to the dorsal and anal fins.

The type specimens of *Dictyopyge* were obtained by Sir Charles Lyell at Blackheath, Va., and were described by Sir Philip Egerton.[1] This fish was previously described by W. C. Redfield under the name of *Catopterus macrurus* in the American Journal of Science, (vol. 41, 1841, p. 27), but Sir Philip Egerton, as cited by Lyell, considered it distinct from the genus *Catopterus*, because "the dorsal fin is more strictly opposite to the anal than in *Catopterus Redfieldi*," and because, "having a homocercal tail, it can not be comprehended in it." Mr. Redfield did not accept the genus *Dictyopyge* of Egerton, because, as he said, *Catopterus macrurus* was really no less heterocercal than the other species of the genus, and with the other common characters the slight difference in the position of the fins had in his judgment only a specific value. There is something to be said on both sides of this question, and perhaps it cannot be settled until we have more material; but by a careful study of that now in hand I have been inclined to accept the genus *Dictyopyge*. In *Catopterus macrurus* of Redfield the opercula are larger, constituting one-half a circle, the scales of the under side of the body are much more numerous, the dorsal fin is more in advance, the anal fin broader, larger, and rounder, and the interhæmal spines by which it is supported are much stronger, and finally the tail is less forked than in the other species of *Catopterus*. In my specimens, as well as in those figured by Sir Philip Egerton, the dorsal fin is decidely in advance of the anal, and both are so

[1] Quart. Jour. Geol. Soc. London, vol. 3, 1850, p. 275.

large and round as to give a peculiar aspect, which will strike the most casual observer. On the other hand, the character of the posterior end of the body is precisely the same as in *Catopterus*, and the anterior margin of each fin is set with the numerous divergent fulcra which are so characteristic of that genus; but in the species under consideration they are more numerous, shorter, blunter, and more divergent. Hence we must conclude that if this fish represents a different genus it is still very closely allied to *Catopterus*.

Sir Philip Egerton, as cited by Lyell,[1] alludes to fragments of another and larger species of *Dictyopyge* from Chesterfield County, Va. This I suppose to be the same fish as that represented by some fragments I have from that region. It was a much larger fish than *D. macrura* and the divisions of the fin rays were marked by several raised lines, constituting a peculiar style of ornamentation.

Johannes Strüver in 1864 published[2] a notice of the Fossil Fishes of the Keuper, of Coburg, Saxony, in which he describes and figures a species of *Dictyopyge* (*D. socialis*) and reviews the structure and relations of the genus. With this notice he also publishes a figure and (p. 305) a description of another fish associated with the last, *Semionotus Bergeri* Ag., to which I have alluded elsewhere. These figures and descriptions are of special interest for comparison with the fishes of our American Trias; for it is probable that, if a few good specimens of *Ischypterus* and *Catopterus* had come into the hands of Agassiz, Berger, Egerton, or Strüver previous to the publications of *Semionotus*, *Catopterus*, and *Dictyopyge*, *Ischypterus* would have been united with *Semionotus* and *Dictyopyge socialis* have been included in *Catopterus*. Judging from Strüver's figures it is impossible to designate any important character by which these fishes could be generically distinguished. *Semionotus Bergeri* has a dorsal fin which is a little broader than that of any of our species of *Ischypterus*, but in all other respects, even to the row of erect and pointed scales on the back, there is the greatest similarity between the two genera; nor are there any differences to which we can give generic value between *Dictyopyge socialis* of the Coburg-Keuper Sandstein and *Catopterus gracilis* of Redfield. It is true that in the former

[1] Quart. Jour. Geol. Soc. London, vol. 3, p. 277.

[2] Zeitschrift Deutsch. geol. Gesellschaft, Berlin, vol. 16, 1864, p. 303–330.

the dorsal fin is exactly opposite the anal, while in the latter the first rays of the dorsal are opposite the middle of the anal, but in another species of *Catopterus* (*C. minor* N.) the position of the fins is exactly that of *D. socialis;* while in the Virginia species, which was taken by Egerton as the type of his genus *Dictyopyge*, the dorsal fin is sensibly anterior to the anal; so that this character can not be considered as diagnostic. Another distinction which Strüver makes between *Catopterus macrurus* (which he erroneously names *macropterus* throughout his article) and *Dictyopyge socialis*, viz. "fulcra der Schwanzflossen ziemlich gross" and "fulcra sammtlicher Flossen fein," does not hold good, for the fulcra are quite as fine in the Virginia as in the Coburg specimens. The only differences which I can specify between our commonest species of *Catopterus* and *Dictyopyge socialis* are the broader operculum, the narrower scales of the belly, and the less deeply forked tail of the latter. In these characters *Dictyopyge macrurus* and *D. socialis* are distinguished from all the species of *Catopterus* found in New Jersey or in Connecticut; and, as I have said elsewhere, these may perhaps afford a raison d'étre for *Dictyopyge.*

DICTYOPYGE MACRURA Egerton.

Pl. XVIII, Figs. 1, 2.

Catopterus macrurus W. C. R., Am. Jour. Sci., vol. 41, 1841, p. 27.
Dictyopyge macrura Egerton, Quart. Jour. Geol. Soc., London, vol. 6, 1850, p. 4.

Fishes small, fusiform; head rather small, surface finely granulated; scales of medium size, those of the sides and back square or slightly rhomboidal, those on the under side of body very numerous and narrow; pectoral fins of medium size, primary rays seven or eight, anterior raylets very fine, short, and close, over forty in number; ventrals small, triangular, and elongated, rays eight or nine, fulcra about thirty; anal very large, quadrate, sometimes reaching as far as base of caudal, rays over thirty in number; tail forked, very long, acute, and spreading, lower lobe longest, rays thirty-five to forty, closely articulated and toward the extremity finely subdivided. Length five inches, breadth one and a quarter inches.

The above description is abbreviated from that of J. H. Redfield. Further details will be found in the discussion of the generic relations.

Up to the present time no specimens of this fish have been found elsewhere than in the Richmond coal basin. There it is locally very abun-

dant; one slab of shale formerly belonging to the Lyceum of Natural History, though scarcely more than a foot square, carried impressions of over twenty individuals.

Genus PTYCHOLĔPIS Ag.

Fusiform, tile-scaled ganoids of moderate size, from six to twelve inches in length; head pointed; fins all delicate and provided with minute fulcra, dorsal triangular in outline placed near the center of the back, pectoral fins pointed, anal fin nearer to the tail than to the ventrals, caudal but slightly heterocercal; the posterior extremity of the body oblique, longer, and rounded on the upper side; scales quadrangular, generally much longer than high, and traversed by furrows which divide the surface into ridges or folds that suggested the name; the posterior margin of the scales notched by the extremities of the furrows; head bones all highly ornamented with raised lines of enamel; teeth small, conical, acute.

Agassiz first described this genus (1843) from specimens found in the Lias at Boll, in Würtemberg. The type he called *Ptycholepis Bollensis*.[1] This was a fish about a foot in length, which has been met with in England and at several places on the Continent of Europe. In 1852 Sir Philip Egerton described another and much smaller species, which he called *P. minor*, obtained from the Lias at Barrow-on-Soar.[2] In 1853 he described and figured still another species very much broader than the last, and called it *P. curtus*.[3] The specimen upon which this description was founded was from the Lias near Lyme Regis.

In 1878 S. W. Loper, of Durham, Conn., found in the Triassic beds, which have yielded so many fishes at that locality, several specimens of still another species of *Ptycholepis*, which came into my possession and were described in the Annals of the New York Academy of Sciences, volume 1, p. 127. Since that time perhaps a dozen more or less complete individuals of this species have been obtained at Durham by Mr. Loper, all of which have passed under my observation. They vary considerably in size, the largest being eight inches long by two and a half broad; the smallest about

[1] Poiss. Foss., vol. 3, p. 107, pl. LVIII bis.
[2] Mem. Geol. Survey, United Kingdom, British Organic Remains, Decade 6, 1852, pl. VII.
[3] Ibid., Decade 8, 1855, pl. VIII.

four inches long; most of them being about six inches long by one and a quarter inches wide. Possibly these specimens represent more than one species, but the material yet found scarcely suffices for the accurate definition of more than one, and it is quite possible that the differences they exhibit are only those of age. I give below the detailed description of this species taken with slight modification, from the paper referred to above.

PTYCHOLEPIS MARSHII Newb.

Pl. XIX, Figs. 1, 2, 2*a*.

Fish eight inches or more in length by two and a quarter in breadth, fusiform, robust; head pointed, contained four and a half times in the entire length; all the bones of the head marked with strong raised lines, those of the upper surface somewhat radiate; on the opercula, maxillaries, mandibles, and gular plates more or less undulately parallel and forked. The dorsal fin is of medium size and placed near the center of the back; the anal is set far back, reaching nearly to the caudal; caudal small, forked, the scales and vertebral column reaching distinctly into the upper lobe. The scales on the anterior portion of the body are two or three times as long as high, and are marked with several longitudinal furrows and raised lines. In the middle and posterior portions they are five or six times as long as high, and are traversed by a superficial furrow, which generally reaches from the anterior end half or two-thirds the length and is again resumed on the posterior margin; by this the extremities of the scales are forked. On the anterior portion of the abdominal surface the scales are exceedingly narrow, acute, and spine-like. Vertebral column partially ossified.

On comparing our fish with the figure and description of *P. Bollensis* Ag. it will be seen that it differs from that species in the position of the dorsal fin (which is placed more anteriorly), in the details of the scales and head markings, and in the greater degree to which the tail is vertebrated and the spinal column ossified. In *P. Bollensis* the scales are covered with fine, simple, parallel ridges of enamel, but in *P. Marshii* the ridges are broader, fewer, and are forked. From *P. minor* Egerton our species is easily distinguished by its greater size, narrower and notched scales, and

more vertebrated tail. From *P. curtus* Egerton it differs in its more elongated form, in the plication of the scales, and the more heterocercal tail.

The discovery in our Triassic rocks of a species of *Ptycholepis*, a genus before found only in the Lias of Europe, might seem to open up again the long-debated question of the age of the New Red Sandstone of the Atlantic States, but in fact it does not seriously invalidate the conclusion, based on other evidence, that this series of strata is the equivalent of the Rhætic beds of Europe. The fish now described is a new species, and has the vertebral column prolonged to a greater distance into the upper lobe of the tail than its Liassic representatives. Without attaching too much importance to this character, we may fairly infer that it indicates a little earlier date.

The two specimens now figured are perhaps about the average in size of all those yet found, but I have one which is eight inches long by two inches wide; another specimen is only four inches long by five-eighths of an inch wide. As a whole our specimens are much smaller than the average of those of *P. Bollensis*. *P. curtus*, of Egerton, from the Lias of England, is no longer than our specimens, but it is much more robust.

I have dedicated this species to Prof. O. C. Marsh, of Yale College. All the specimens yet known have been obtained by S. W. Loper. at Durham, Conn.

Genus ACENTROPHORUS Traquair.

From the Triassic rocks at Chicopee Falls, Mass., a considerable number of little fishes have been obtained which are distinctly different from any others found in this country. Their affinities with *Ischypterus* are so close, that I was for a long time disposed to consider them as belonging to a species of that genus. The structure is essentially the same throughout, with the exception that the crest of spinous scales which crowns the dorsal arch in *Ischpyterus* is here wanting and the median line is marked by a series of round or oval scales a little larger than the quadrangular ones which accompany them on either side. The body is fusiform or conical, widest near the head, tapering gradually with nearly straight lines above and below; the fins are all weak, the dorsal placed far back, nearly as far, indeed, as in *Catopterus*. The structure of the fin is like that of *Ischyp-*

terus, viz, relatively large spinous fulcra border the margins, the rays are few and widely separated, the caudal is narrower than in most species of *Ischypterus*, and the inequality of the extremity of the body—i. e., the heterocercy—is about the same as in *Ischypterus*, and considerably more marked than in *Catopterus*.

Searching for allies of these little fishes among the figures and descriptions which have been published I find in Agassiz's *Palœoniscus glaphyrus* and in the three fishes described by J. W. Kirkby,[1] and called by him *Palœoniscus altus*, *P. Abbsii*, and *P. varians*, what perhaps may be members of the same genus. More material, and that in a better state of preservation will be required, however, before a satisfactory comparison can be made. It is perhaps not certain that the group referred to all belong to one genus. For example, *Palœoniscus altus* of Kirkby very closely resembles our small ovoid species of *Ischpyterus* (*I. latus*), differing, so far as I can see, only in this, that none of the median row of dorsal scales in *P. altus* are spiny. Dr. R. H. Traquair—who has made a careful study of the fishes described by Mr. Kirkby—considers this a character of generic value, and it has led him to place all the group of Ischpyterus-like fishes (*Palœoniscus glaphyrus*, *P. altus*, *P. varians*, and *P. Abbsii*) in a new genus, which, from the absence of spiny scales, he calls *Acentrophorus*.[2]

In the Chicopee fishes the structure, so far as can be made out, is altogether that of *Ischypterus*, except that the median dorsal scales are all rounded or ovoid. Unfortunately the details of the head structure are obscured by the metamorphosis to which the inclosing rocks have been subjected. The teeth are, however, distinctly shown, and they prove to be conical, pointed, and relatively strong. The form of the body is more elongated than in most species of *Ischypterus;* in that respect resembling Kirkby's *Palœoniscus varians* and *P. Abbsii*, but the dorsal fin is placed farther back than in those fishes or in any species of *Ischypterus* known. It is, in fact, but little in advance of the anal. All the fins, including the caudal, have the structure of those of *Ischypterus*, having few and many-jointed rays and long spiny fulcra, but all are relatively weak.

[1] Quart. Jour. Geol. Soc. London, vol. 20, 1864, p. 353.
[2] Quart. Jour. Geol. Soc. London, vol. 33, 1877, p. 565.

The size and number of the spiny scales of the dorsal line vary much in the different species of *Ischypterus*, and it is not quite certain how far these scales can be accepted as a generic character. For example, in some specimens of *I. tenuiceps*, Ag. sp., the scales of the dorsal line immediately back of the head are enormously developed, being more than half an inch long, erect, radiate, and club-shaped, forming a salient crest, which gives a very striking aspect to the fish. On the other hand, in *I. latus* J. H. R. the anterior scales of the dorsal line are oval and not spined, while the scales back of these, though spined, are generally depressed and inconspicuous.

In the figure of *Palæoniscus altus* published by Mr. Kirkby[1] the form is almost exactly that of the specimens of *Ischypterus latus* from Plainfield, N. J., and the size is but little less. The head bones, scales, and fins seem to be quite the same, only no spined scales appear in Mr. Kirkby's figures and descriptions. If this should be made a generic character, these two so-closely allied little fishes must be separated, but if the differences noticed above between *P. tenuiceps* and *P. latus* should be found to exist in equal or greater degree among other species, they should be given only specific value.

The disparity in form between *Palæoniscus altus* Kirkby and *P. varians* Kirkby would seem to be associated with some other characters which suggest a generic distinctness; for example, the operculum is large and rounded in the latter, narrow and crescent-shaped in the former. That *P. altus* and *P. glaphyrus* are members of the same genus can hardly be doubted; but whether *P. varians* and *P. Abbsii* should be united with them may perhaps be questioned. The form of the body is certainly very different, and in *P. altus* the operculum is semilunar and the branchiostegals are scarcely visible (characters common to *Ischypterus*), while in *P. varians* and *P. Abbsii* the opercula, including subopercula, are nearly round and the branchiostegals are very conspicuous.

ACENTROPHORUS CHICOPENSIS, n. sp.

Pl. XIX, Figs. 3, 4.

Fishes six inches long by one and three-eighths inches wide, greatest breadth near head, from which point the body slopes equally above and

[1] Loc. cit.

below to the tail; head broad and obtuse, as wide as the body, about one-quarter the entire length; teeth conical, relatively large; dorsal line nearly straight, fins relatively small, dorsal and anal placed far back on body; dorsal midway between occiput and tip of tail and much behind middle of body; anal when depressed reaching nearly to base of caudal; ventrals nearer to anal than to pectorals; caudal narrow and weak; scales of medium size, apparently all smooth, those of the median dorsal line round or oval without spines.

A large number of fishes of this species are contained in the collection presented to Yale College by J. H. Redfield. They are from the same locality, Chicopee Falls, Mass., and are nearly of the same size. They are contained in a rather coarse sandy shale, which has been considerably metamorphosed by the proximity of trap-rock. This has obscured some of the details of structure, such as the surface of the scales, the shape and markings of the head bones, etc., but has left the outlines of the body and the position and form of the fins distinctly visible. The most striking characters of these fishes are the narrow, wedge-shaped form of the body, the straightness of the dorsal and ventral lines, the smallness of the fins, the posterior position of the dorsal, and the rounded and unarmed margins of the median dorsal scales. As mentioned above, these seem sufficient to warrant our placing them in a distinct genus, and since they are in most respects very similar to the group of fishes upon which Dr. Traquair has founded his genus *Acentrophorus*, it seems best to refer them at least provisionally to that.

Order CROSSOPTERYGIDÆ Huxley.

Family CŒLACANTHINI Ag.

Genus DIPLURUS Newb.

Fishes of large size, fusiform in outline, having, in common with other members of the Cœlacanth family, a depressed and pointed muzzle, somewhat angular occiput, two dorsal fins supported on interspinous bones, a dyphycercal caudal fin traversed by the spinal column which bears at its extremity a small supplemental caudal; the pectoral and ventral fins lobate,

the anal nearly opposite the posterior dorsal. The scales are ovoid in outline, relatively thin, imbricated, with one-third to one-half the surface exposed, and this ornamented with raised enamel lines. The bones of the head and pectoral arch are granulated, or ornamented with raised, tortuous, interlocking, and interrupted ridges. The air bladder was ossified, the vertebral column cartilaginous, and having disappeared in fossilization, its place is represented by a smooth band, which is continuous from the head to the extremity of the tail In the caudal and supplemental caudal fins the course of the spinal cord is marked by rows of scales of diminished size. The neural and hæmal spines were ossified, and are distinctly shown in the fossil state. The rays of the caudal fins were supported by interneural and interhæmal spines, to the extremities of which they are attached by sheathing splices. As in all the other members of the family, the fin rays are hollow, and the sides are frequently crushed together in the fossil state, but in *Diplurus* the walls were strong and the rays generally retain their forms. As in *Holophagus* and some of the living siluroids (*Doras*, *Plecostomus*, etc.), the fin rays are coated with short, closely-set, acute spines. The dentition is yet unknown, not being shown in any of the specimens found up to the present time. Whether the teeth were flat and obtuse, like those of *Undina*, or acute, as in *Cœlacanthus*, remains to be determined by further observation.

Diplurus shows throughout its structure all the characteristic features of the remarkable family to which it belongs. Its resemblance to *Cœlacanthus*, *Holophagus*, and *Macropoma* is so close, that if they all occurred in the same geologic formation we should hardly be justified, with our present knowledge, in regarding them as more widely separated than are different species of the same genus. This similarity among the members of the family has been noticed by Professor Huxley in his remarks on *Cœlacanthus*, *Holophagus*, *Undina*, etc.[1]

It is one of the most surprising and interesting facts in the history of fishes that this family should appear so suddenly, spread over the whole northern hemisphere, retain all the details of its highly specialized structure through the Carboniferous and Mesozoic ages, and then disappear as

[1] Mem. Geol. Survey United Kingdom, British Organic Remains, Decade 10, 1861.

suddenly as it came, leaving among the Tertiary and living fishes no descendants which can be affiliated with it. In the description of *Cœlacanthus elegans*[1] I have referred to the close resemblance and possible identity of this little fresh-water fish with *C. lepturus*, which lived in the lagoons in the coal marshes of England. Not only are all details of internal structure the same, but the elaborate ornamentation of scales and head plates presents no tangible differences.

From *Holophagus* (with which *Diplurus* seems to be most closely allied) its only obvious differences are the finer striation of the scales, the wider separation of the two caudal fins, and the fewer articulations of the fin rays. In *Holophagus* and *Undina* and in the Jurassic species of *Cœlacanthus* described by T. C. Winkler[2] the supplemental caudal fin seems to spring directly from the extremity of the caudal. In *Diplurus* there is a distinct interval between them; a character which suggested the name *Diplurus*, or double-tail. Judging from the specimens of *Holophagus gulo* which I recently had an opportunity of examining, both the original of Sir Philip Egerton's generic description and the more complete one figured by Professor Huxley,[3] I should say that this was a shorter and broader fish than our *Diplurus*. Sir Philip Egerton's specimen is much smaller, but it wants the head, and can not be fully compared. In the body traces of another fish are visible, which had apparently been swallowed. This would show that *Holophagus* was carnivorous. The scales of *Holophagus* are ornamented with relatively few short, broad, divergent ridges of enamel, while our species of *Diplurus* has many fine parallel thread lines on the scales.

In my description of the first specimens of *Diplurus* found I reported the fin rays to be smooth and the scales granulated, but that specimen was from Boonton, N. J., and was buried in a coarse, sandy shale, in which the minute spines of the fin rays were not discernible, and the thread lines of the scales were broken into granules by the grains of sand. Other and better specimens found later at Durham, Conn., show the characters now described.

[1] Rept. Geol. Survey Ohio, vol. 1, pt. 2, Paleontology, 1873, p. 339.
[2] Archives Musée Teyler, vol. 3, pp. 101–116.
[3] Mem. Geol. Survey United Kingdom, British Organic Remains, Decade 13, 1872.

T. C. Winkler has described two Cœlacanth fishes which may be compared with *Diplurus*. Of these, the first is from the Solenhofen (Jurassic) limestone, and he has called it *Cœlacanthus Haarlemensis*.[1] This is in some respects imperfectly preserved, but is apparently distinct from any other described fish, although it deserves more careful comparison with *Holophagus gulo* Egerton. The specimen upon which Mr. Winkler's description was based is a fish about one foot in length, of which the outlines are fringed and somewhat obscured by dendritic crystallizations of manganese common in the Solenhofen fossils. The scales have all disappeared, but some indications of their surface markings are visible at certain points. If correctly reported these consist of fine, parallel, nearly straight lines running in an antero-posterior direction. This fish would also seem to be peculiar in the strength of the ventral fins, which are represented as fully equal in size to the dorsals. In this character it seems to be distinguished from all other known members of the family. The surface markings of the scales are like those of our *Diplurus*, but that fish is much larger, the ventral fins are not so strong, and the supplemental caudal is more distinctly separated.

The second of the two species described by Mr. Winkler he called *Cœlacanthus giganteus*.[2] This was obtained from the Trias of Würzburg. Its derivation makes it of special interest for comparison with *Diplurus*, because no other Triassic Cœlacanth is known. Unfortunately, however, the specimen described by Mr. Winkler is a mere fragment. This indicates a fish of enormous size. The caudal fin rays, the only ones yet known, are six inches long and as large as goose quills; the supplemental caudal is represented as small and as closely approximated to the anterior caudal.

Whether these fishes described by Mr. Winkler should really be included in the same genus with the species of *Cœlacanthus* from the Coal Measures and Permian remains to be seen. The general structure of all the members of the family is so like, that much more material and that well preserved, will be necessary before exact comparison can be made. It is probable that the teeth will furnish the best diagnostic characters. The teeth of our Carboniferous *Cœlacanthus* are certainly conical and

[1] Archives Musée Teyler, vol. 3, p. 101. [2] Ibid., vol. 5, p. 147.

acute, as is shown in several specimens in my possession. The teeth of *Holophagus* can hardly be said to be known; those of *Undina* are stated by Count Münster and by Professor Huxley[1] to be pavement-like and tuberculated; finally, those of *Macropoma* are conical and acute.

Diplurus longicaudatus Newb.

Pl. XX, Figs. 1–5.

Diplurus longicaudatus Newb., Annals New York Acad. Sci., vol. 1, p. 127.

Fish attaining a length of three feet and a breadth of eight or ten inches; body fusiform, symmetrical; head pointed, sloping rapidly down from the occiput; back gently arched, anterior dorsal fin strong, supported by a semicircular bone; posterior dorsal placed nearly opposite to the anal fin and midway between the anterior dorsal and the extremity of the body; caudal fin very long, supported by thirty-two ? long and strong rays, which are spliced on to the interneural and interhæmal spines; supplemental caudal separated from the caudal fin by a distinct interval; in form it is an equilateral triangle about three inches on a side; the web of this fin is supported by about nine simple fluted rays above and below, of which the bulbous bases were inserted into the cartilaginous extremity of the vertebral column, as posts are set in the ground; paired fins strongly lobate; anterior fin rays of these and the two dorsal fins roughened by many short, conical, acute spines; teeth unknown; scales ovoid, half an inch in diameter, the exposed portion occupied by fine parallel raised lines, running from front to rear.

Only four specimens and the head of a fifth have yet been found of this the largest of our Triassic ganoids, and all these are now in the Geological Museum of Columbia College. Two of these specimens were obtained in excavations made at Boonton, N. J.; the others were collected by S. W. Loper at Durham, Conn.

The smaller of the Boonton specimens is figured on Pl. XX of this memoir. This is interesting, as showing the general form of the fish, the position of the fins, etc., but the details of structure are not distinctly perceptible. Another and much larger specimen was found at Boonton, but it

[1] Mem. Geol. Survey, United Kingdom, British Organic Remains, Decade 10, 1861, p. 17.

lay near the surface and was so much decomposed that it supplied little information, except as regards size; it was about three feet in length.

The description of the genus and species published in the Annals of the New York Academy of Sciences was taken from the Boonton specimens, and, from their imperfect preservation, was in some respects erroneous. One of the specimens obtained at Durham, though wanting the muzzle and having the tail much decomposed, exhibits in other respects the beautiful preservation characteristic of the Durham fishes. This shows the ornamentation of the scales copied on Pl. XX, Figs. 3–5, and spines on the fin rays. Another quite imperfect specimen found at Durham was flattened vertically, and shows a broad rounded head like that of a salamander, but this outline is doubtless due to compression. Four out of the five specimens of *Diplurus* known were found lying on the side, from which we may infer that like most fishes it was broader vertically than transversely, and that the rounded head of the specimen referred to above was the result of an unnatural position accidentally assumed.

It is somewhat surprising that no distinct teeth can be discerned in any of the heads of *Diplurus* yet found, though some impressions at the extremities of the mandibles of one of the Boonton specimens indicate but do not prove that the teeth were conical and acute. This is the character of the teeth of *Cœlacanthus* and *Macropoma*, and it is probable that *Diplurus* was the enemy and devourer of the many species of smaller ganoids with which it was associated. Numerous large coprolites are found in the same beds, and it would seem natural to refer them to *Diplurus*, but it is somewhat remarkable that none of these coprolites have yet shown any traces of bones or scales such as we might expect to find in the excreta of fishes which lived on ganoids.

In the absence of teeth we can not certainly determine whether *Diplurus* was carnivorous or herbivorous. The coprolites referred to afford good evidence that the Triassic estuaries contained in considerable numbers a large fish which did not feed on the various scaled ganoids that abounded in the same waters. On the other hand, it should be said that the head bones of *Diplurus*, including cranium, opercula, maxillaries, and mandibles, were all well ossified, much more so indeed than those of *Catopterus* or

Ischypterus; from which we may infer that the dental apparatus was employed in serious and severe work of some kind. The only vegetable remains found in the fish-beds of New Jersey and Connecticut are those of land plants—fronds of cycads and twigs of conifers—and it is hardly probable these could have formed the subsistence of *Diplurus*. Mollusks and Crustaceans are entirely absent; so, unless he devoured the scaled ganoids, of which the remains are so abundant, it is difficult to imagine of what his food could have consisted. His structure shows that he was a swift and powerful fish, and his congeners were carnivorous. We may expect therefore that, when his dentition shall be discovered, that will solve the problem, by demonstrating his carnivorous habits.

PART III.

FOSSIL PLANTS OF THE TRIASSIC ROCKS OF NEW JERSEY AND THE CONNECTICUT VALLEY.

SKETCH OF TRIASSIC FLORA.

The number of fossil plants obtained from the Triassic rocks of the valley of the Connecticut and from New Jersey is not large, and as a general rule they are not well preserved. A sufficient number of fairly good specimens have, however, been collected at Sunderland, Mass., Durham and Middletown, Conn., and at Newark and Milford, N. J., to demand a brief notice.

These include the following species:

Schizoneura planicostata Rogers, sp.
Equisetum Rogersi Schimper.
Equisetum Meriani? Brong.
Clathropteris platyphylla Brong.
Palissya Braunii Endl.
Palissya diffusa? Emmons, sp.
Baiera Münsteriana Saporta.
Baiera multifida Fontaine.
Otozamites latior Saporta.
Otozamites brevifolius Fr. Braun.
Cycadinocarpus Chapini Newb.
Pachyphyllum simile Newb.
Pachyphyllum brevifolium Newb.
Cheirolepis Münsteri Schimper.
Loperia simplex Newb.
Dendrophycus Triassicus Newb.
Dioönites longifolius Emmons, sp.

In addition to these are many ill-defined plant remains, some of which indicate genera and species new to science; others are decorticated stems and branches, apparently of coniferous trees, probably *Palissya*. Some of these are quite plain and smooth, but others are marked with lozenge-shaped figures resembling a *Lepidodendron* from which the bark was stripped, while the outlines of the rhomboidal leaf scars remained. These have been sometimes called *Lepidodendra*, but without warrant, and we have no evidence that any species of *Lepidodendron* passed from the Paleozoic into the Mesozoic Age.

No real plant-beds have been found in the northern Triassic areas, and all the remains of plants yet met with seem to be floated fragments, that here and there sank to the bottom of the basin and were buried in the accumulating sediments. In the sandstones, which were transported by rapid currents or were formed by shore waves, delicate plants and the foliary appendages of trees would naturally be triturated and destroyed, and in the quarries from which building stone is taken at Newark stems and branches, with an occasional cone, are all the plant remains that have survived the rough treatment which they have received. These are, however, so numerous in some of the layers, that they prove the former existence of land covered with vegetation at no great distance

At Milford, N. J., the plants are more numerous and somewhat better preserved. There we find the stems of *Equisetum* and *Schizoneura*, with many twigs and some cones of conifers. The *Equiseta* not unfrequently show the diaphragms which partitioned off the stems at the joints, and, with other things, we sometimes meet with disks or flattened cones of which the surface is radiately striate and which have considerable resemblance to some of the woody fungi, *Polyporus*, etc. These I have supposed may have been the diaphragms of *Equisetum Rogersi*, but they are not sufficiently well preserved to justify any positive assertion in regard to their botanical relations.

At Durham, Conn., the fronds of cycads and ferns are not uncommon, and one specimen obtained by Mr. Loper shows a number of fronds of *Otozamites* radiating from what seems to have been the summit of a stem. The fern fronds, too, are grouped in such a way as to illustrate the radiate arrangement of the pinnæ in *Clathropteris*.

The quantity of carbonaceous matter in the shales here is large, and is so generally diffused that we must conclude it was largely derived from the decomposition of plant tissue. This indicates the proximity of a considerable amount of growing vegetation at the time of the deposition of the shales, and it is possible that somewhere near this locality plant-beds will be found which will afford a better view of this vegetation.

In the Portland quarries casts of the trunks and branches of trees are not unfrequently met with, but they are always imperfectly preserved, and

we can only conjecture that they represent coniferous forests which grew on the highlands at no great distance. Here, too, the remains of what seem to be sea-weeds of a peculiar character are found in considerable abundance. These show a striking resemblance to plants which have been obtained from the Umbral shales of Pennsylvania and which have been named *Dendrophycus* by Leo Lesquereux. The similarity is so great, that I have ventured to describe them as a species of this genus, and have called them *Dendrophycus Triassicus*. They will be found figured and described more in detail in another part of this memoir.

At Hadley's Falls, Sunderland, and, more rarely, at Boonton, the layers of shale are frequently covered with fragments of twigs of a conifer which has been sometimes referred to as a *Voltzia*, but, though the foliage is dimorphous, some of the twigs are clothed with closely appressed, scale-like leaves, while on others they are divergent, though always short and thick. One cone-bearing twig of this plant, found at Sunderland, shows distinctly that it is not a *Voltzia*, but is rather a *Pachyphyllum*.

This plant is apparently the same with that which has been considered by Fontaine as identical with *Cheirolepis Münsteri* of Schimper, but the cone referred to shows that it is not *Cheirolepis*, the scales being small and the exposed surfaces rhomboidal. At Milford, N. J., however, cones and detached scales are found which apparently do belong to *Cheirolepis*, and perhaps to *C. Münsteri*. Numerous leaf-bearing twigs associated with these cones show that the foliage was symmetrical and even elegant in character. The branches spread in the same plane and, terminating in twigs pinnately arranged, regularly diminishing in length, present somewhat the appearance of *Thuja* or *Moriconia*, but the form of the leaf is quite different, being short and triangular, similar to that of some species of *Pachyphyllum*.

DESCRIPTIONS OF GENERA AND SPECIES.

DENDROPHYCUS TRIASSICUS, n. sp.

Pl. XXI, Figs. 1, 2.

In the Geology of Pennsylvania, by H. D. Rogers (vol. 2, Pl. XXIII), is represented a fossil plant which is designated as an "algoid resembling a *Desmarestia*." This is fossilized in the red shale of the "Umbral," a part of the Lower Carboniferous formation in northern Pennsylvania. The fossil consists of a number of branching stems from which are thrown off slender dichotomous branches from either side, and these branches, cylindrical like the stems, support numerous opposite or alternate simple branchlets. No reference to this plant is made in the text, but it is evident that it is what it is represented to be, a sea-weed, though its affinities with the living algæ may be a matter of doubt.

In the Report of the Second Geological Survey of Pennsylvania (vol. 3), Coal Flora, by Leo Lesquereux, a figure is given (Pl. I) of what is apparently the same plant as that figured by Rogers. This is briefly described[1] under the name *Dendrophycus Desorii*. It is said to occur in the red shale below Pottsville, and also abundantly in the bluffs of the Susquehanna above Pittston.

Splendid specimens of this plant are reported by Mr. Lesquereux[2] as occurring "near Davenport, Iowa, in a bed of clay and hardened sandrock, traversing like a dike the Corniferous limestone overlaid by the Hamilton group." In his description of this plant Mr. Lesquereux says:

> The roots or radicular appendages, * * * are apparently cylindrical or tubulous, * * * often branching at right angles, three or four mm. in diameter, of

[1] Op. cit., pp. 699, 700.

[2] Op. cit., p. 701.

coriaceous or horny texture shining on the surface. * * * The rhizoma is 1.20 to 1.50 m. long, perfectly cylindrical, 3½ to 4 cm. in diameter, simple and regular in its whole length, with a rough surface. * * * The top of the rhizoma, abruptly enlarged into a globular shape resembling a cabbage head 17 cm. in diameter, looked, when broken, like a convolute undeveloped frond, with branches densely rolled together into a ball where the divisions or the relative disposition of the branches could not be distinctly observed. The fronds, very large, 1 to 1.25 m. long by 50 cm. broad, are composed of cylindrical divisions, the primary and secondary ones being thick, the larger 2 cm. in diameter, flattened on the surface, all gradually smaller from the base to their ends, closely distichous, dichotomous, flexuous, with oblique multiple subdivisions, the ultimate two-ranked being very closely pinnately distichous, cylindrical, pointed, or gradually narrowing from the middle and effaced at the apex.

I have copied this description nearly entire because it is almost literally applicable to a plant represented on Pl. XXI of this memoir and obtained from the sandstones of Portland, Conn. When we consider the vast interval of time between the deposition of the Umbral shale of Pennsylvania and that of the Rhætic sandstone of Connecticut, one the base of the Carboniferous system and the other the summit of the Trias, it can not fail to be regarded as interesting and surprising that the resemblance should be so complete. But for the a priori improbability that a species of sea-weed should be so long-lived I should hardly feel justified in giving even a new specific name to the Triassic specimens. Possibly a comparison of more material would show differences not now perceptible, but the peculiar mode of growth and the details of structure seem to be essentially the same. In the Portland sandstones, as in the Umbral shales, the fronds of *Dendrophycus* are enrolled in masses that suggest cabbage-heads of large size and rather loose texture, while the mode of subdivision and the character of the final ramifications of the frond are so like that, with the similarity of the inclosing rock, the specimens from the two localities and horizons are almost undistinguishable. Though a less conspicuous example of a "persistent type" than *Strophomena rhomboidalis* or *Atrypa reticularis* the survival of a sea-weed of such strongly marked character through so great an interval is as unexpected as it is interesting.

Spirophyton, which begins in the middle Devonian (Corniferous) and runs up into the Coal Measures, is another example of persistence in an allied group of algæ; but that genus is represented at the different horizons by

quite different species. One found in the Waverly has the frond divided very much as in *Dendrophycus*, while in other species in the same rock the fronds are simply plicate or swollen into bullæ apparently by vesicles which served as floats.

Baiera Münsteriana Ung.

Pl. XXII, Fig. 1.

We here give a representation of one of many specimens of a species of *Baiera*, found by Mr. S. W. Loper at Durham, Conn.

Taken by itself, the larger of these specimens (Fig. 1) would seem to represent a species closely allied to *B. Münsteriana*, but somewhat taller and more slender than any described variety of that species. Other fragments, however, show that the fronds were sometimes much shorter and broader, and therefore more like the normal form, so that at present we have scarcely evidence that would justify us in separating them.

On Pl. XXIII is figured a fine specimen of a gigantic *Baiera*, described by Professor Fontaine in his monograph[1] with the name *B. multifida*. This specimen is from Clover Hill, Va., and it is figured to show the close resemblance between the Virginia and Connecticut plants; the former is much more robust, but the characters of the ultimate divisions are essentially the same, and the northern plant may only be a dwarf form of the southern.

In my descriptions of the plants collected by Mr. A. Remond, from the Triassic rocks of Los Bronces, Sonora, I have noticed and figured another and quite different species of *Baiera*, to which I gave the name of *Jeanpaulia radiata*, the generic name being practically synonymous with *Baiera*.[2]

Count Saporta has recently discussed at great length the probable relations of the groups of plants which have been known by the names of *Baiera*, *Jeanpaulia*, etc.[3] He regards them as belonging to a special line of gymnosperms which have come down to us from Carboniferous times, and are now represented by the *Gingko* (*Salisburia*).

Schimper[4] also describes the relations of *Baiera* and *Jeanpaulia* to each

[1] Mon. U. S. Geol. Survey, No. 6, 1883, pp. 87, 88.
[2] Report of the San Juan Expedition, p. 148; pl. VII, fig. 6.
[3] Paléontologie française, Végétaux, vol. 3, 1883, p. 251.
[4] Paléontologie végétale, vol. 1, pp. 422, 682.

other and to other plants, and he takes the apparently sensible view that the Wealden *Cyclopteris digitata* Brong. (*Baiera digitata* Schenk) and the Rhætic *Jeanpaulia Münsteriana* Ung., though perhaps members of the same botanical group, were generically distinct.

Brongniart and Unger regarded *Jeanpaulia* as one of the *Rhizocarpæ*, allied to *Marsilia*, but Schenk considers it a fern. He also supposes that it is allied to *Hausmannia* of the Wealden. Its relation with the later genus is, however, very doubtful.

From the Amboy clays of New Jersey, the basal portion of the Cretaceous system, and resting immediately upon the Triassic beds, I have obtained many specimens of *Hausmannia*, and, though there is a remote resemblance in the mode of the division of the frond, there is a radical difference in the nervation, and they probably have nothing in common.

Equisetum Rogersi Schimper.

Pl. XXII, Figs. 5, 5*a*.

As is mentioned in the preceding sketch of the plants of the northern Trias, *Equisetum Rogersi* occurs at Milford, N. J. It is quite abundant in the Richmond coal field and is mentioned by many writers who have referred to the plants of that region, Rogers, Brongniart, Bunbury, Schimper, and others. It is so fully described by Professor Fontaine in his monograph (p. 10) that only a brief reference to it is needed here.

Some specimens obtained at Milford, N. J., now in the collection of Lafayette College, which I have been permitted to examine through the courtesy of Prof. T. C. Porter, exhibit features which are worthy of remark. One of these, a compressed stem, $6^{cm.}$ in diameter, has the joints below only $2^{cm.}$ apart, and on these are set in spiral arrangement disks which mark the attachment of branches or roots such as we so frequently find in some species of *Calamites* from the Coal Measures. These disks are much distorted and obscured, but they would seem to have been elliptical in outline, $2^{cm.}$ long by $1\frac{1}{2}^{cm.}$ wide.

In the same rocks and associated with stems of *Equisetum* are the discoid or low-conical, radiately striate bodies which I have already referred to

and have supposed were the diaphragms of *Equisetum*. As these have not been before figured I give herewith representations of the flattened base of a small one and the conical, striated upper (?) surface of another.

Equisetum Meriani (?) Brong.

Some years ago Mr. J. B. Woodworth, now of Boston, Mass., then living in Newark, N. J., sent to me, with a number of other fossil plants taken from the sandstone quarries near that city, several fragments of a large plant which gave no clew to its entire form, but of which the surface was differently marked from anything I had before obtained from our Trias. The fragments were flattened, only a few inches square, and the surface was deeply impressed by a series of parallel, angular furrows and ridges, three-eighths of an inch wide.

The general aspect of the fossil was very like that of a fan-palm, such as we frequently find fossilized in the Tertiary rocks. It had also somewhat the aspect of a *Sigillaria*, but the sharply angular form of the folds and the absence of leaf scars forbade the supposition that we had here a relic of the great fluted trees of the Coal period.

In reviewing the literature of the Triassic flora I have found[1] what are apparently representations of the same plant. The fossils figured by Schenk are considered by him as portions of the stems of *Equisetum Meriani* Brong. (*Calamites Meriani* Heer), a well-known plant of the Upper Trias of Europe, later placed by Schimper in his genus *Schizoneura*.

Until the fructification of these Equisetoid plants of the Trias shall be found which will permit a better comparison with those of older and later formations, it is a useless expenditure of time to discuss the question whether they are species of *Calamites* which have survived from the Carboniferous age, are true *Equiseta*, or are species of an extinct genus of that family. It will be remembered that in the Permian rocks stems of *Calamites* have been found a foot or more in diameter (*C. gigas*, Brong.), on which the longitudinal ridges are as broad as in the specimens before us, but in these the ribs are rounded and not angular, as are those of the specimens from Newark.

[1] Schenk's Beiträge zur Flora des Keupers und der Rhätischen Formation, Bamburg, 1864, pl. VIII, figs. 1*a*, 1*b*.

This latter character may not, however, be a constant feature, as Schenk gives a figure of one specimen[1] in which the ribs seem to be rounded.

More material must be obtained before much can be said about the botanical character of these specimens, but they possess much geological interest from their evident similarity to those with which I have compared them, and their occurrence at the same horizon confirms the testimony of other fossils as to the Rhætic age of our sandstones.

SCHIZONEURA PLANICOSTATA Rogers, sp.

Portions of the stems of this plant, so common in the Triassic rocks of Virginia, are occasionally met with in New Jersey, Connecticut, and Massachusetts.

This was first described by Prof. W. B. Rogers as a *Calamites*, of which it has very much the aspect, indeed, specimens of *Calamites Cistii*, Brong., from the Coal Measures could hardly be distinguished from the plant under consideration in some stages of preservation.

Professor Fontaine, in the Monograph cited (p. 14), has described this plant from far better specimens than any which occur at the north, and has given reasons for uniting it with *Schizoneura* of Schimper. Certainly the stems bear a close resemblance to those of the group of plants which have been described by Schimper, Schenk, Nathorst, and others, and found in the Trias and Lias of Europe. But we have never seen any foliary appendages which come very near to those of *S. paradoxa* figured by Schimper and Mougeot in their monograph on the fossil plants of the Grès Bigarré. It is probable that the leaves were narrowly linear, somewhat like those of *Schizoneura Virginiensis* Fontaine, and were deciduous like the foliary appendages of *Calamites*, which are so rarely found in connection with the stem. The only interest that attaches to the imperfect specimens yet found in the northern Triassic basins comes from the evidence they furnish of a close relationship between the deposits which contain them and those of Virginia.

[1] Op. cit., pl. VIII, fig. 1*a*.

PACHYPHYLLUM SIMILE, n. sp.

Pl. XXII, Fig. 2.

Foliage dimorphous, on the large branches appressed, sometimes scale-like, on the smaller twigs longer, crowded or open, leaves triangular or falciform, keeled, pointed.

In the Triassic rocks of New Jersey, Connecticut, and Massachusetts slender detached twigs of coniferous trees are frequently met with, but they are usually fragmentary and not well preserved. They show two forms of foliage, the appressed and the divergent, and they vary much in their strength; some twigs being very slender, with comparatively remote leaves, while on others the leaves are longer and more crowded. These differences are so marked that I have been led to think the specimens represent two species. Both these forms are represented on Pl. XXII, Fig. 2, the stronger and more leafy branches; Figs. 3, 3*a*, 3*b*, the more slender twigs, with shorter leaves. To the first I have given the name *Pachyphyllum simile* from its resemblance to *P. peregrinum* of the Jurassic. The other I have called *P. brevifolium*. As will be seen by comparing Fig. 2 with the representation of *P. peregrinum* given by Saporta,[1] there is a marked resemblance between them, but our plant never assumes the form shown in the figures of *P. peregrinum* given by Lindley and Hutton[2] or by Saporta on Pl. XLVI of the volume just quoted. The two species are evidently allied but are quite distinct.

This plant has been before found in America and has been figured and described, though from bad specimens and erroneously. Prof. E. Emmons[3] represents a twig from Turner's Falls, Mass., the locality from which that now figured was obtained. It is evidently the same thing, but is badly figured and wrongly named *Walchia*. It does not belong to that genus and can be referred with confidence to *Pachyphyllum*. Professor Fontaine, in his Monograph, Pl. XLVII, Figs. 6, 7, represents twigs which are essentially identical with the form now figured from Turner's Falls. The larger of these two twigs is copied from Professor Rogers's paper, but no locality

[1] Paléontologie française, végétaux, vol. 3, 1883, pl. XCVII.
[2] Fossil Flora, pl. LXXXVIII.
[3] Am. Geol., pt. 6, 1857, p. 108, fig. 76.

is given. By Fontaine it is referred to *Cheirolepis Münsteri*, but I have elsewhere shown that it can not be a *Cheirolepis;* we find *C. Münsteri* at Milford, N. J., but it is plainly distinguishable from this both by cones and by foliage.

PACHYPHYLLUM BREVIFOLIUM, n. sp.

Pl. XXII, Figs. 3–3*c*.

Foliage dimorphous, on some branches closely appressed and scale-like, on terminal twigs divergent, though the leaves are always short and relatively broad. Cones ovoid, one inch in length; scales rhomboidal, closely appressed.

In many localities the Triassic rocks of New Jersey and the Connecticut Valley, especially where they are fine, gray, or more rarely reddish shales, contain great numbers of slender coniferous twigs, generally short and much broken up. Of these two forms are now figured which may be recognized as typical. Figures 3 and 3*a* the more leafy, and 3*b* the more scaly form. Sometimes we find twigs bearing leaves that are longer than those here shown; leaves that are divergent, rather open, sometimes spatulate, and never really acute. These may be a phase of the foliage of the present species, but they more probably belong to *P. simile*, showing a similar diversity of form to that seen in the figures of *P. peregrinum* given by Saporta.[1]

The plant under consideration has been noticed by Emmons and Fontaine; by the former it was considered a *Walchia*, and given the two names *W. brevifolia* and *W. gracilis*.[2] Professor Fontaine[3] refers it to *Cheirolepis Münsteri* Schimper; but the discovery of ovoid cones having small rhomboidal scales with twigs of this plant, and of digitate cone-scales with branches bearing more acute leaves, have shown its distinctness from the true *Cheirolepis Münsteri*.

The specimens represented in Figs. 3*a* and 3*c* are from Turner's Falls; those in Figs. 3 and 3*b* from Durham, Conn.

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[1] Paléontologie française, végétaux, vol. 3, pl. XLVIII, figs. 2, 3.
[2] Am. Geol., pt. 6, 1857, pp. 107, 108, figs. 74, 75.
[3] Mon. cited, pp. 88, 89.

Cheirolepis Münsteri Schimper.

Pl. XXII, Figs. 4, 4*a*.

In my general sketch of the Triassic flora I have referred to this plant, and have said perhaps all that it is necessary to say in regard to it. I will only add that the foliage which I have described as expanded in the same plane, and having somewhat the general aspect of that of *Thuja* or *Libocedrus*, closely resembles that figured by Schenk in his Fossile Flora der Grenzschichten, and the cone scales are also nearly identical with those he represents; so that there would seem to be no good reason why they should be regarded as distinct. Schenk calls this plant *Brachyphyllum Münsteri*, but Schimper has shown that the digitate cone scales separate this from all other species of that genus, and he makes it the type of his *Cheirolepis*. The pinnate arrangement of the branchlets of our plant, which must have given it the general aspect of *Thuja*, though the leaves are quite different, is not shown in Schenk's figures, and it is therefore possible that this will constitute a specific distinction; but with so many other characters in common it is scarcely probable that this is not also shared by the European and American plants.

Otozamites latior Saporta.

Pl. XXIV, Figs. 1, 2, 2*a*.

On another page of this memoir I have referred to the geological importance of this plant, which is one of the several species common to our Upper Triassic rocks and the Rhætic of Europe. Up to the present time we have found this only at Durham, Conn., but it is there quite abundant. The general character of the fronds is fairly represented in the figures now given. They are from one foot to perhaps two feet in length, and from two to three inches wide; broadest in the middle, where the obliquely set pinnules are two inches in length, narrow, linear, and pointed. Toward the summit of the frond they are shorter and more crowded, while near the base they are still shorter and somewhat irregularly placed. On the upper side of the rachis the bases of the pinnules are elegantly adjusted to one another in alternate order, the line of contact between them being sinuous or

zigzag. The bases are auricled, the upper lobe is greatly developed, the attachment being at a single point, and from this the fine and parallel nerves radiate to all parts of the margin after the manner of the genus as shown in Fig. 2*a*.

On a slab of slate now in the possession of Mr. S. W. Loper, at Durham, several of the fronds are shown radiating from a central area, probably the summit of the stem. Of the stem itself, which was doubtless somewhat succulent, we have as yet found no traces.

Locality, black shales, associated with *Ischypterus*, *Catopterus*, etc., Durham, Conn.

Otozamites brevifolius F. Br.

Pl. XXIV, Fig. 3.

Among the many fronds of *Otozamites* obtained at Durham there are some of small size, set with short, crowded, rounded, or blunt-pointed pinnules. These correspond perfectly to some of the specimens of *Otozamites brevifolius* figured by Saporta, Braun, Schimper, and Schenk. One of these is represented on Pl. XXIV. We have not yet sufficient material for comparing these fronds with those which I have referred to *Otozamites latior*, but it has seemed to me possible that these two forms, which are here and in Europe so frequently intermingled, may be but varieties of the same species, the smaller fronds belonging to small plants or representing a special stage of growth. Whether this is true or not, it is a matter of much interest that we here find fronds which correspond so perfectly to those common in the Rhætic of Germany and France.

In Schenk's admirable memoir, Die fossile Flora der Grenzschichten, Pls. XXXI, XXXIII, and XXXIV, a series of excellent figures are given which perfectly represent our Durham cycads, both the larger and the smaller forms (*Otozamites latior* and *O. brevifolius*).

By Schenk they are considered to be ferns, as they were by Lindley, and he unites the two forms under the name of *Otopteris Bucklandi*. Probably they should be united, but it is hardly possible that they are ferns.

Locality, Triassic shales, Durham, Conn., collected by S. W. Loper.

Cycadinocarpus Chapini Newb.

Pl. XXIV, Fig. 4.

Fruit broad-ovoid, nearly orbicular, 15 mm. wide by 18 mm. long, compressed, consisting of an ovoid nucleus bordered by a wing or margin which is emarginate or notched above, narrowed and becoming obsolete below; nucleus excavated in a broad sulcus, extending from the base to the center of the fruit, and traversed centrally by a depressed line.

This interesting specimen was obtained at Durham, Conn., by Rev. J. H. Chapin, to whose courtesy I am indebted for the opportunity of examining it. It is plainly the fruit of a cycad, and perhaps of *Otozamites latior*, which is quite common at the locality where it was found. It probably consisted originally of a hard, ovoid, compressed nucleus, surrounded by a sarcocarp covered with a leathery rind. When compressed in fossilization the nut is shown in relief, and the envelope forms the margin about it. The fruit of *Cycas revoluta* would present much the same appearance if subjected to compression in clay. A large number of cycad fruits are known, but there is none described with which I have been able to identify this.

Dioönites longifolius Emmons, sp.

Pl. XXV, Fig. 4.

One specimen only of this plant has yet been found in the Trias of New Jersey, and that was taken from the quarries at Newark by Prof. C. H. Hitchcock. It apparently represents the basal portion of a frond of large size, the rachis being very strong. The pinnules of only one side are shown. These diverge at a large angle, are linear, attached by the entire base, and are decurrent. Their complete length is not shown, but they must have been at least two inches in length. They are separated by intervals of about twice their breadth. The nervation is obscure, but apparently fine and parallel. In many cycads the basal pinnules of the fronds are shorter, and in some more widely separated than those above. They also diverge from the rachis at a larger angle. It is almost certain that if we were to obtain the upper portion of the frond of which we here have the base we should find the pinnules more approximated and diverging at a more acute angle than is the case with those now before us. Hence we

should have specimens closely resembling those figured by Dr. Emmons. Of these, one (his Fig. 83) represents the middle part of the frond; the other (Fig. 82) is from a higher portion. This is inferable from the fact that in one the rachis is stronger and the pinnules are more separated and diverge at a larger angle than in the other.

Dr. Emmons does not describe the nervation, but represents it as fine and parallel. This would exclude it from the genus *Cycadites*, in which the pinnules are traversed by a strong midrib. Both Dr. Emmons's species and that now figured belong clearly to *Dioönites*, as defined by Schimper.[1]

Loperia simplex, n. sp.

Pl. XXV, Figs. 1, 2, 3.

One of the most common plants found in the Trias at Durham, as usually seen, is a straight, smooth, unjointed stem, once cylindrical, but now much compressed and replaced by jet. Of some of these stems portions have been obtained an inch or more in width and twelve or fifteen inches in length, but the plant was evidently a large one, and these are mere fragments of it. Recently Mr. S. W. Loper has found specimens which show more of this organism than was before known, and some of these are represented in our plate. Of these, that best preserved consists of a stem such as I have described, but which divides above into a number of branches, all springing from the same point. These branches are slender and flexuous, and bear what seem to be alternate, linear, acute, grass-like leaves, but in their state of preservation showing no nervation. This is apparently the same plant as that figured by Emmons[2] and copied by Fontaine.[3] Professor Fontaine refers to these specimens on pages 119 and 120,[4] and "for convenience of reference" gives them the name of *Bambusium Carolinense*. I venture to substitute for that name the one now given, as it is quite certain that the plants under consideration had no close botanical relationship with *Bambusa* (the Bamboo), which is a grass, and, like all the *Gramineæ*, has jointed stems. Without more material it will be impossible to determine with any certainty the botanical relations of this plant, but it was most probably monocotyledonous, perhaps aquatic—a kind of gigantic

[1] Paléontologie végétale, vol. 2, p. 147.
[2] Am. Geol., pt. 6, 1857, pp. 131, 132, figs. 99, 100.
[3] Monograph cited, pl. LII, figs. 1, 2.
[4] Op. cit.

Schollera. The plant figured by Emmons[1] is perhaps the summit of a stem which divides into five branches, and his figure 102[2] represents a smaller specimen with four divisions. This he compares with *Baiera*, but I am led to doubt its connection with that genus, both from its manner of branching and from the fact that, associated with the larger stems described above, I have one even smaller than that represented by Emmons, in which the stem terminates above in five nearly equal branches

CLATHROPTERIS PLATYPHYLLA Brong.

Pl. XXII, Fig. 6.

At Sunderland, Westfield, and Durham, in the Connecticut Valley, fronds of *Clathropteris* have been frequently met with. Much more rarely fragments of the same fern have been obtained from the coarser beds of Newark and Milford, N. J.

In 1855 Edward Hitchcock, jr., described[3] a portion of a frond of *Clathropteris* found near Easthampton, Mass., about the middle of the Triassic series. To this plant he gave the name of *C. rectiusculus;* but it has the radiate arrangements of the lobes or pinnæ which is characteristic of *C. platyphylla* Brong., and its details furnish no characters, judging from his figure and description, by which it can be distinguished from that species. *Clathropteris platyphylla* is a very widely distributed fern in the Liassic and Rhætic strata of the Old World, from England to India and China, and it has been collected by Professor Fontaine in the Virginia coal series. Fronds which I can not distinguish from those of this species also occur not unfrequently at Durham, Conn. These are always imperfect, but were evidently of large size and had a digitate or radiate arrangement of the pinnæ.

The fragment now figured is a portion of the upper part of a pinna, from the sandstone of Newark, N. J.

PALISSYA? sp.

Pl. XXVI, Figs. 1, 2.

I give herewith representations from photographs of two views of a coniferous trunk such as is frequently found in the sandstone quarries at

[1] Am. Geol., p. 131, fig. 99. [2] Op. cit., p. 133. [3] Am. Jour. Sci., 2d series, vol. 20, 1855, p. 22.

Newark, N. J. The decorticated surface of these stems is marked by rhomboidal elevations, which somewhat resemble the markings on the trunks of *Lepidodendron* when denuded of their coaly envelope. This resemblance has led to the announcement that *Lepidodendron* had been found in our Triassic rocks, but this is a manifest error. *Lepidodendron* did not pass from the Carboniferous to the Mesozoic age, and these are plainly casts of the trunks of coniferous trees.

Since this was written my attention has been drawn to a figure of the trunk of *Voltzia Coburgensis* Schaur (Palæontographica, vol. 11, p. 308, Pl. XLVI, Fig. 2). This is so much like the trunk now figured and the smaller ones not uncommonly met with in the quarries at Newark, that if we had anywhere found in the Trias of this region any certain traces of *Voltzia* I should have little hesitation in referring our specimens to that genus; but no *Voltzia* has yet been found in the New Jersey sandstones, while *Palissya* is rather common. Hence, I have been led to believe that these trunks and branches bearing lozenge-shaped markings belonged to the latter genus. As it was doubtless closely allied to *Voltzia* it would not be at all surprising if we should find that the decorticated trunks of trees of the two genera were much alike.

PLATES.

PLATE I.

PLATE I.

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ISCHYPTERUS OVATUS W. C. R., Boonton, N. J. 27

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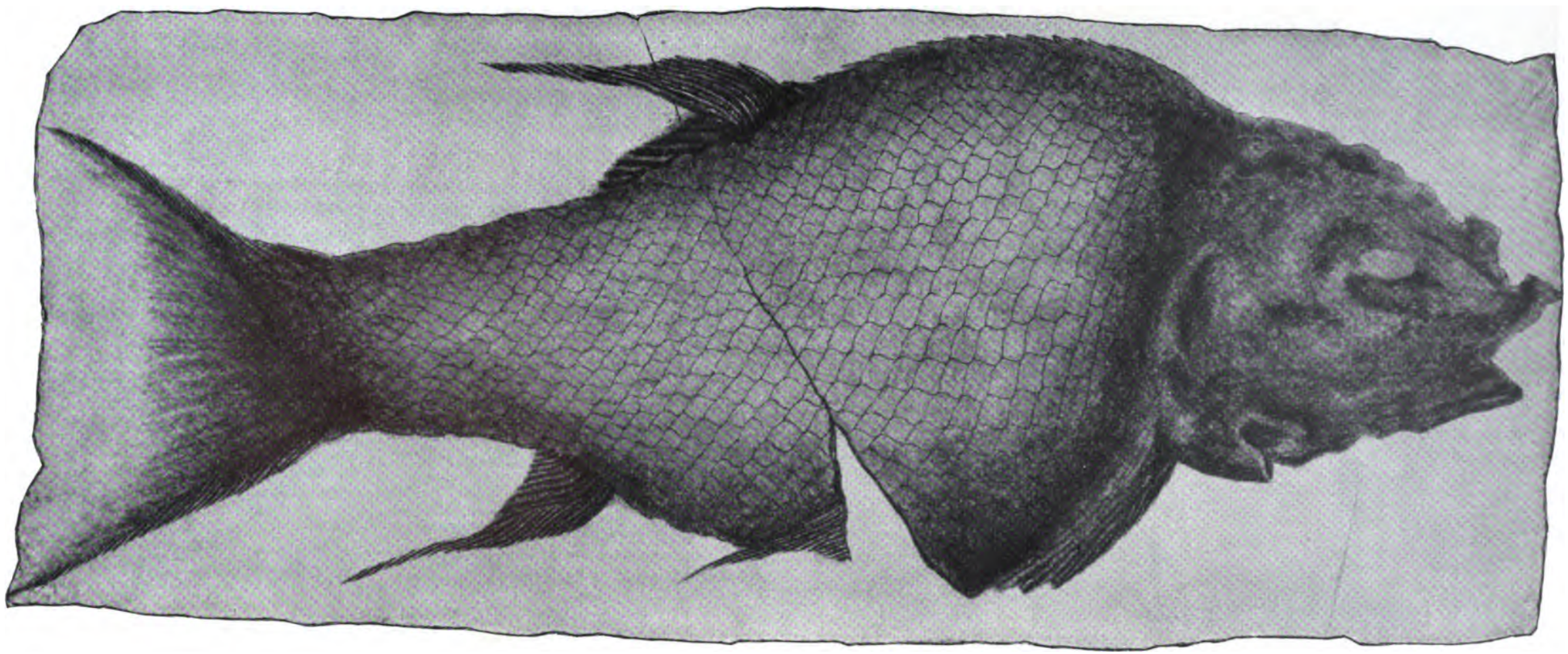


ISCHYPTERUS OVATUS.

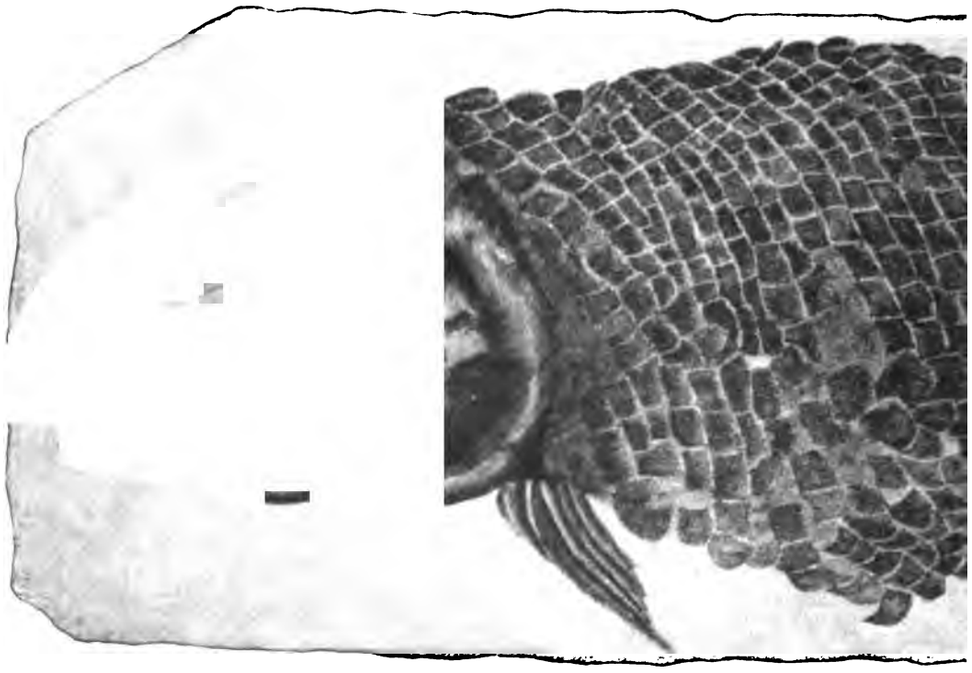
PLATE II.

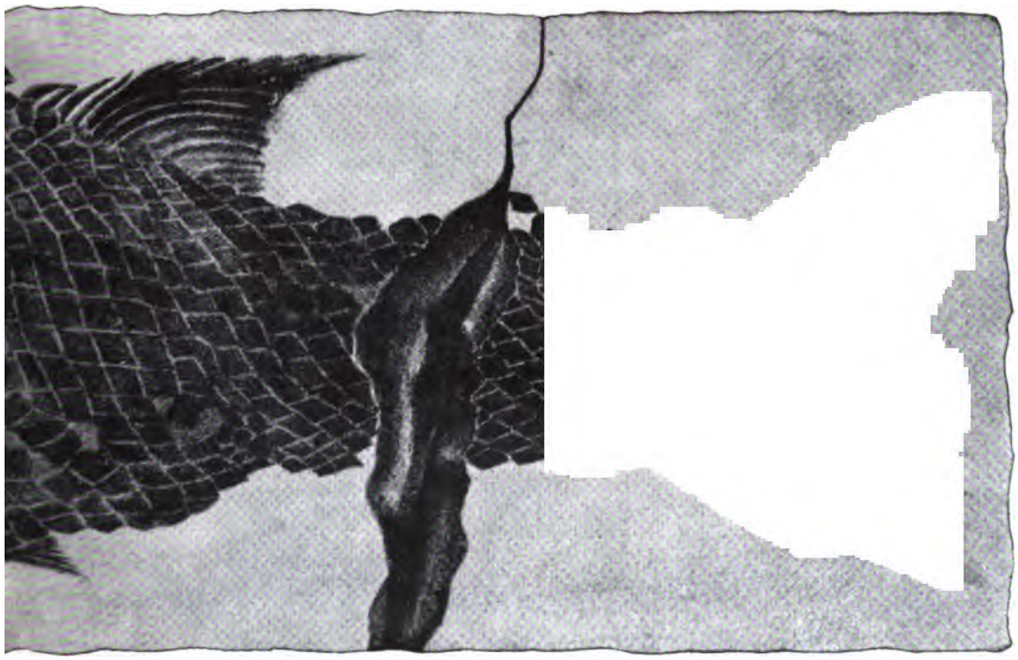
PLATE II.

Page.

ISCHYPTERUS MARSHII W. C. B., Sunderland, Mass. 28

102





IS MARSHII.

PLATE III.

PLATE III.

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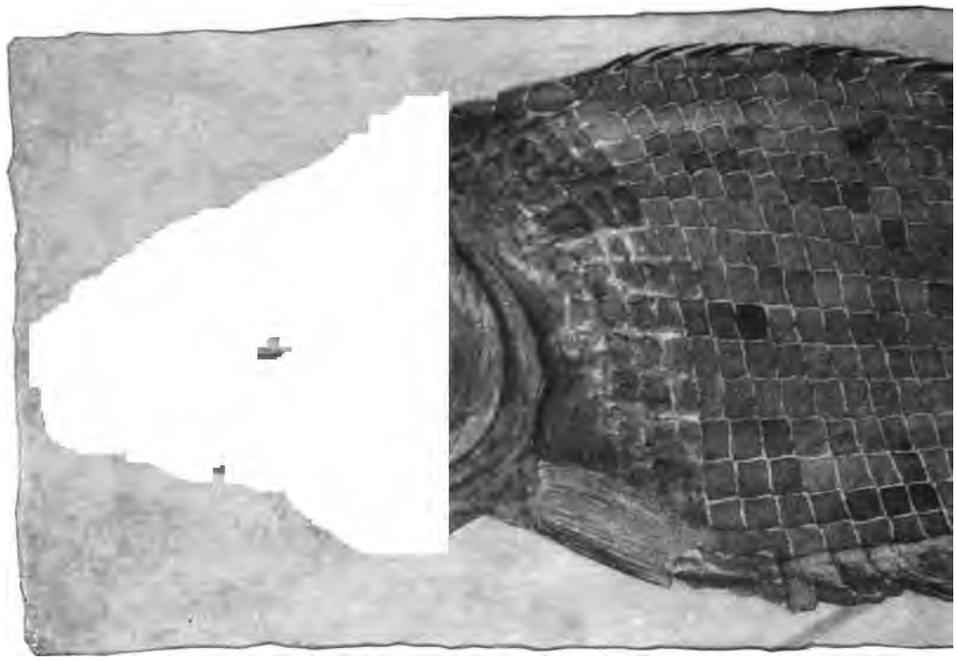
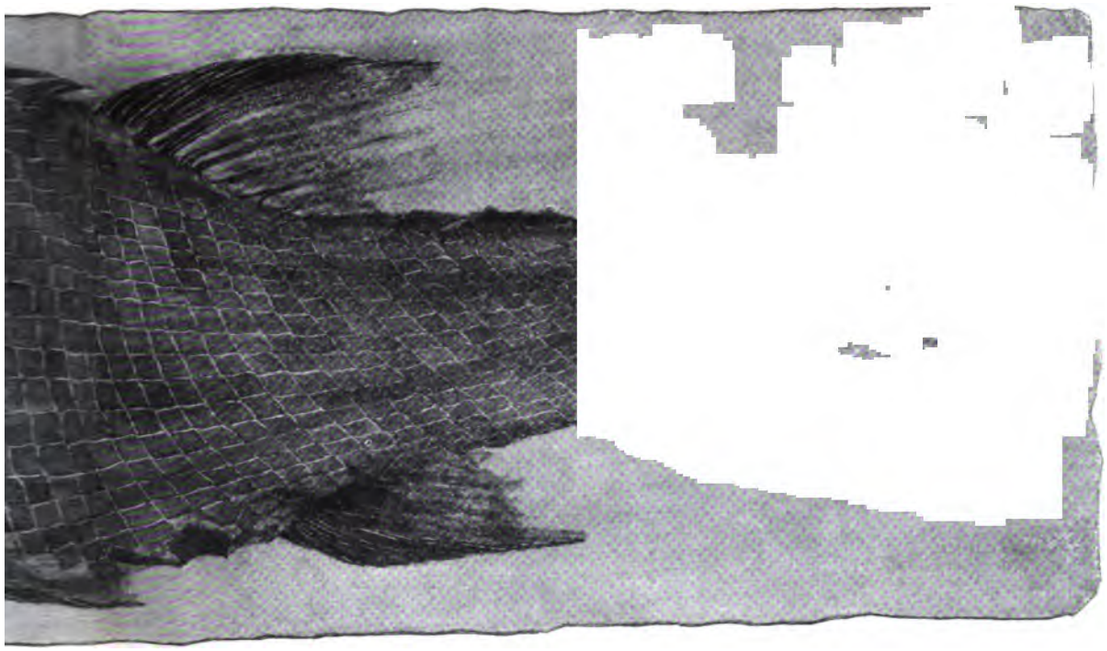
ISCHYPTERUS AGASSIZII W. C. R., Boonton, N. J 30

U. S. GEOLOGICAL SURVEY





SCHYPTERUS AGASSIZII.

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PLATE IV.

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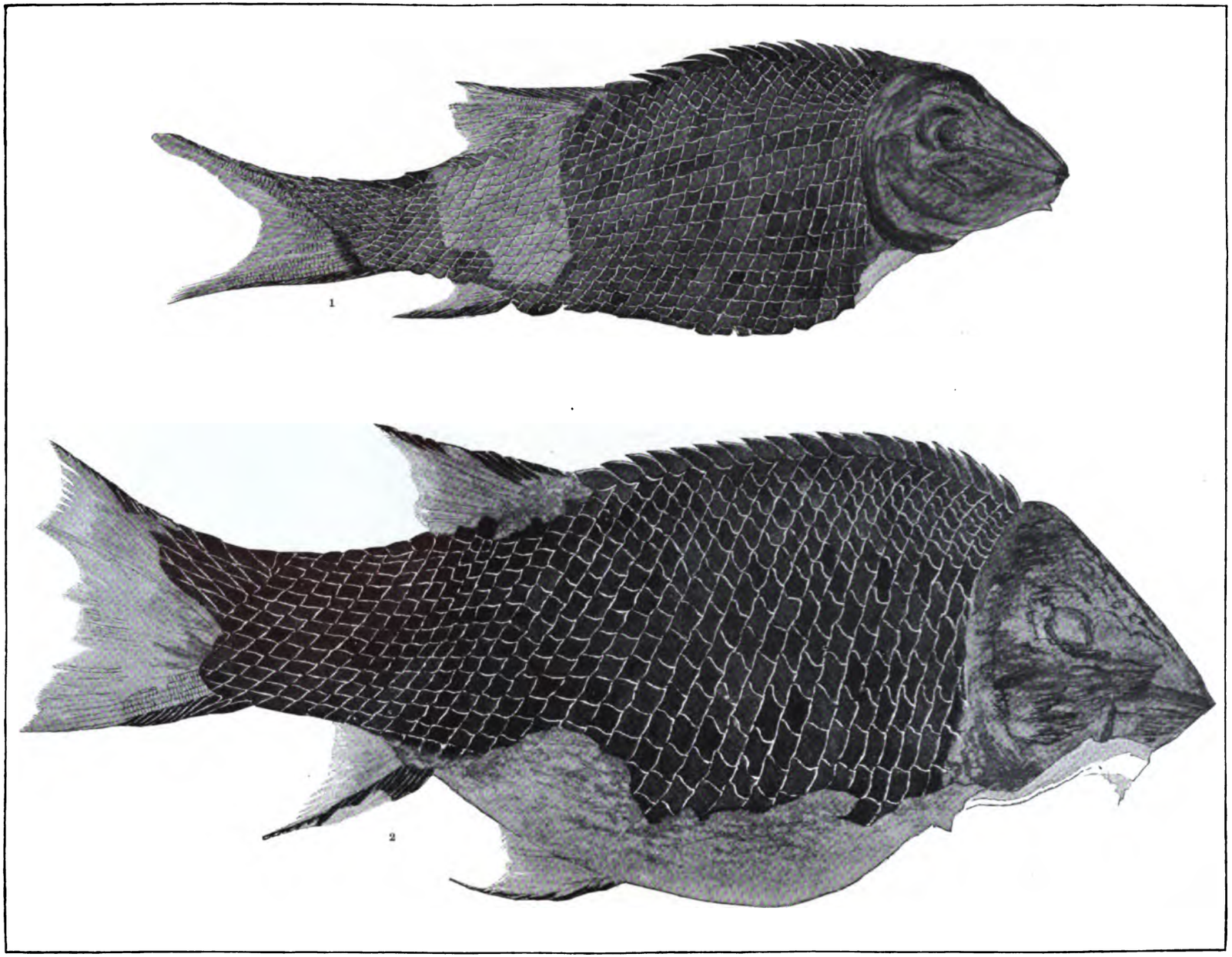

ISCHYPTERUS MICROPTERUS.

PLATE V.

PLATE V.

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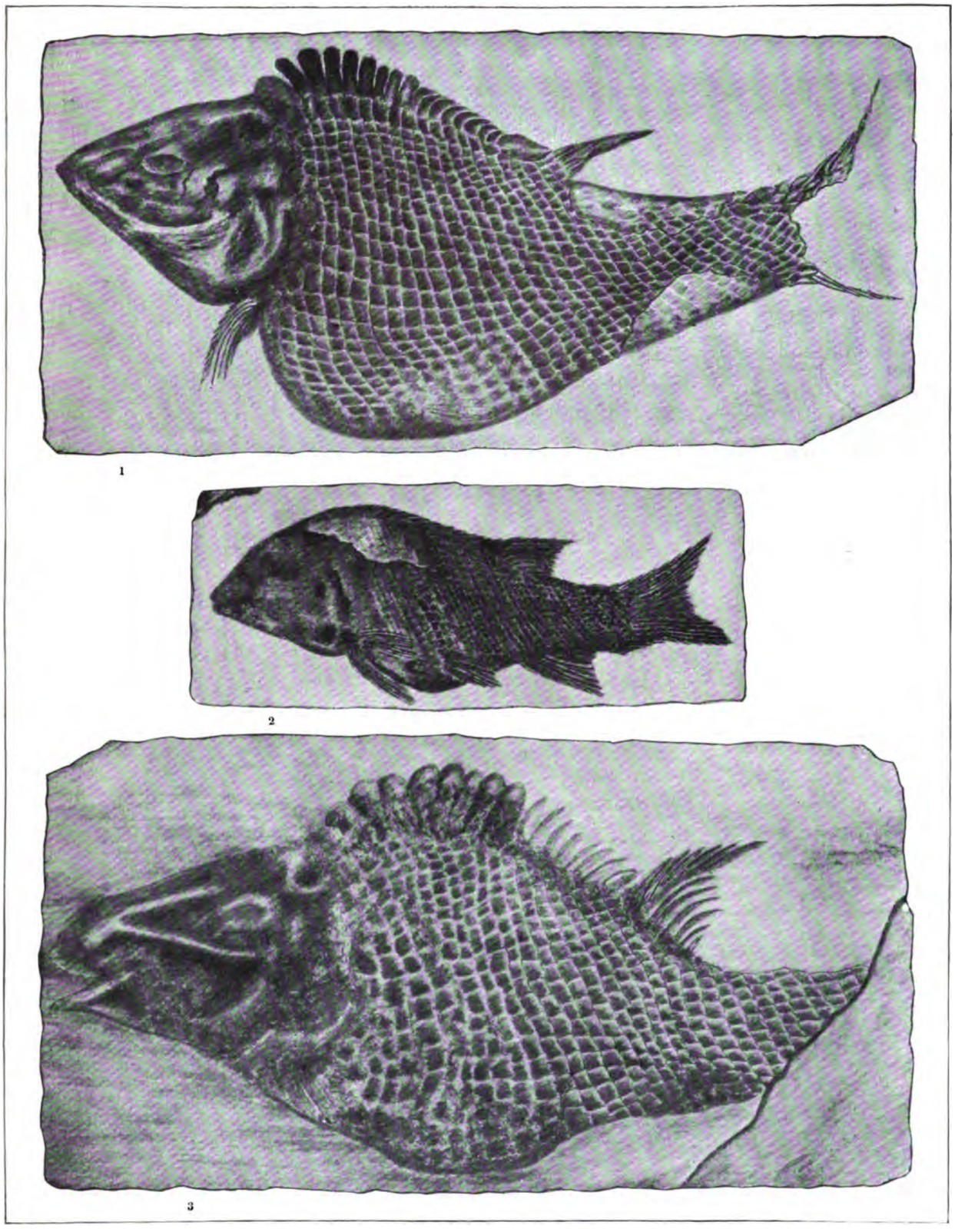

1

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ISCHYPTERUS TENUICEPS.

PLATE VI.

PLATE VI.

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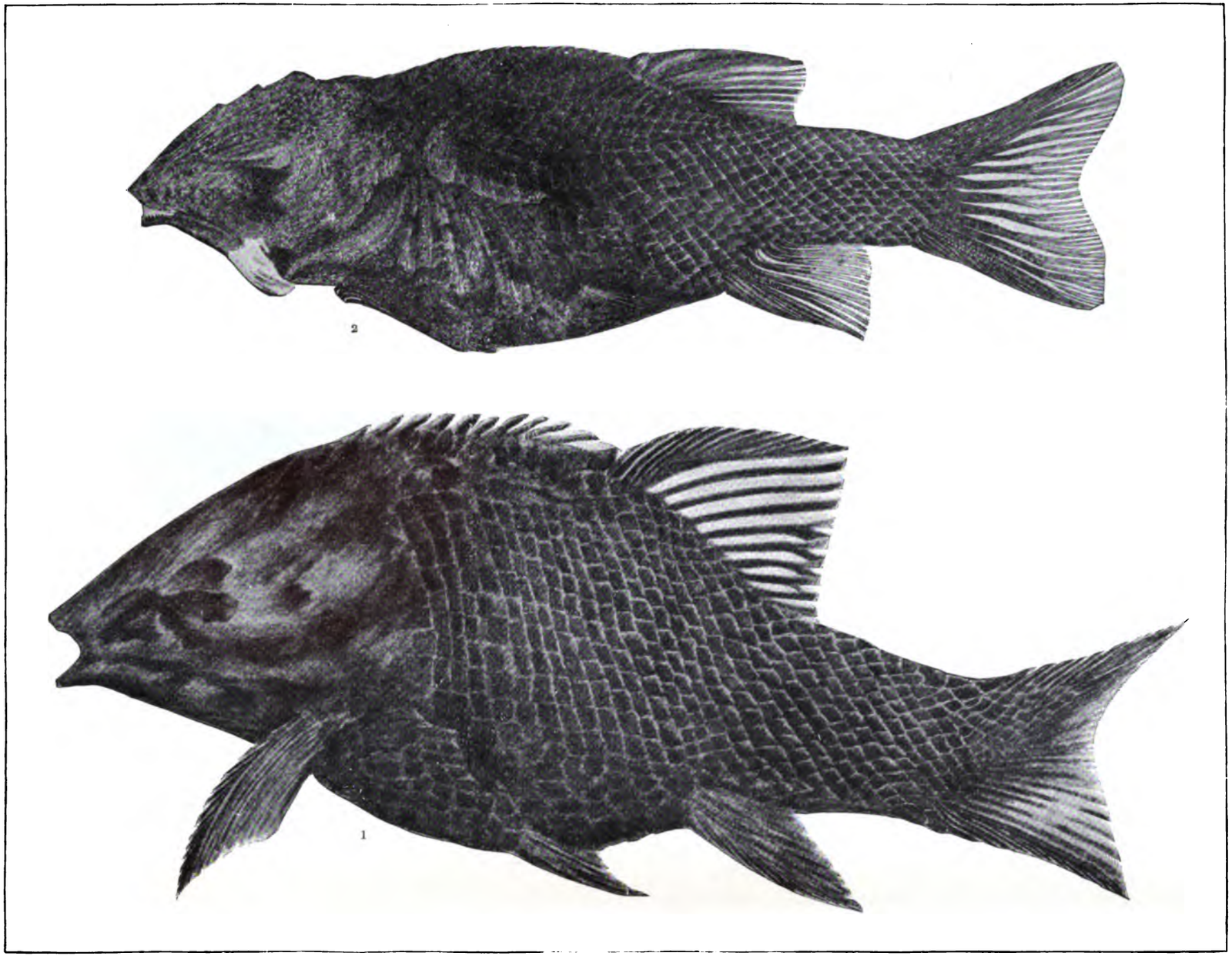
2. ISCHYPTERUS FULTUS Ag., Boonton, N. J 34



1. ISCHYPTERUS ROBUSTUS.

2. ISCHYPTERUS FULTUS.

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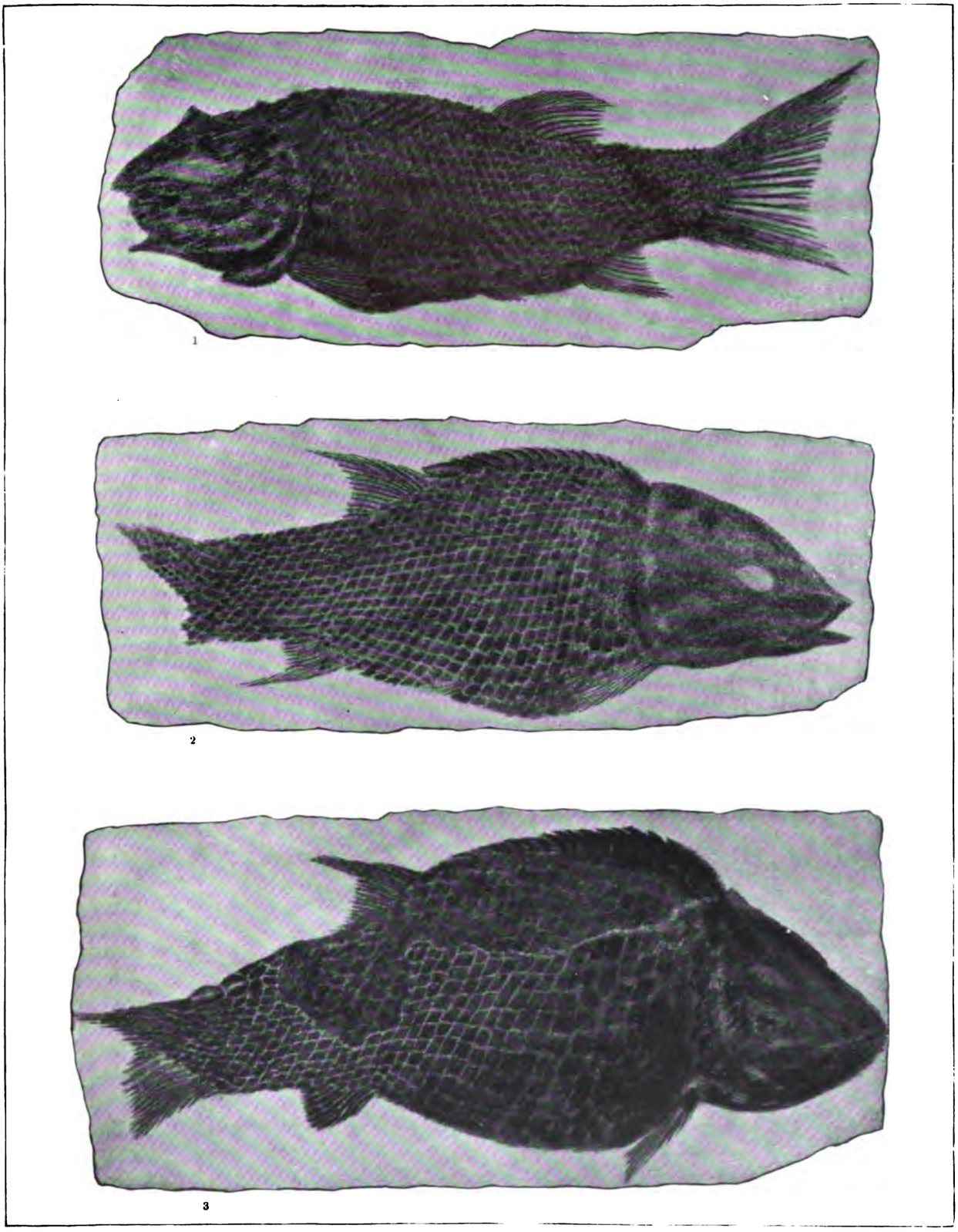

1. ISCHYPTERUS FULTUS. 2. ISCHYPTERUS ELEGANS. 3. ISCHYPTERUS TENUICEPS.

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PLATE VIII.

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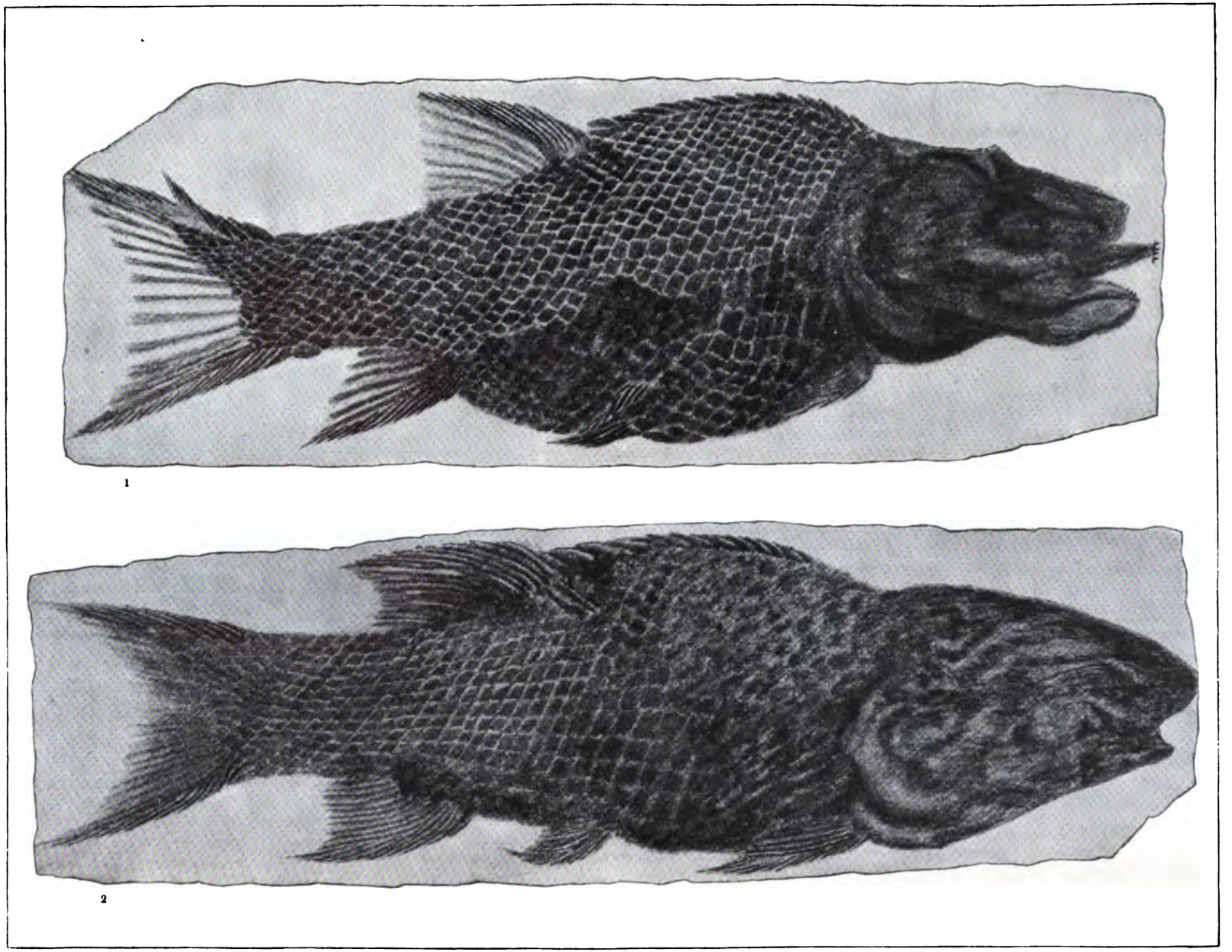
2. ISCHYPTERUS ALATUS Newb., Boonton, N. J. 37



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ISCHYPTERUS ALATUS.

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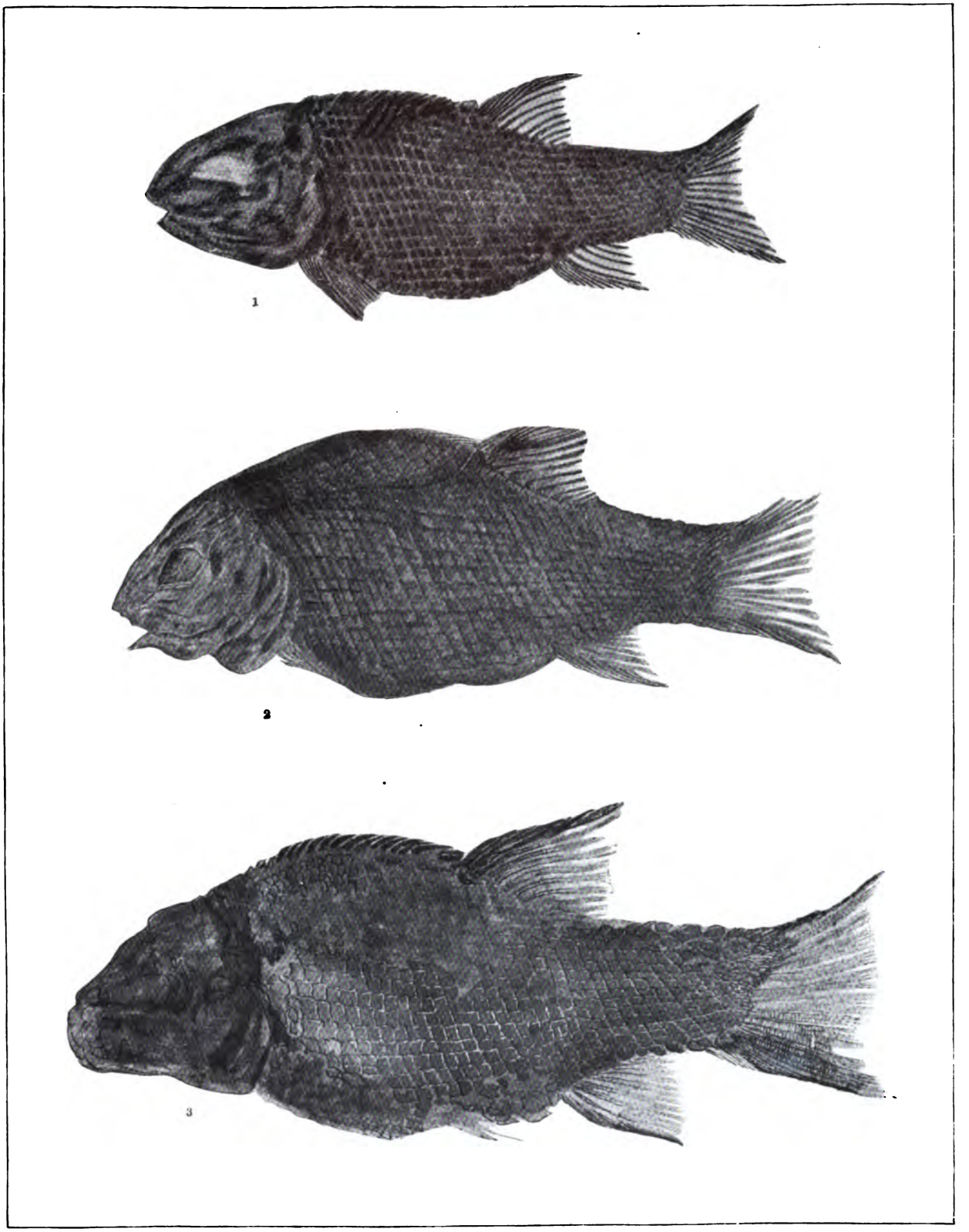
2. Mature individual	38
3. Old individual	38



ISCHYPTERUS MODESTUS.

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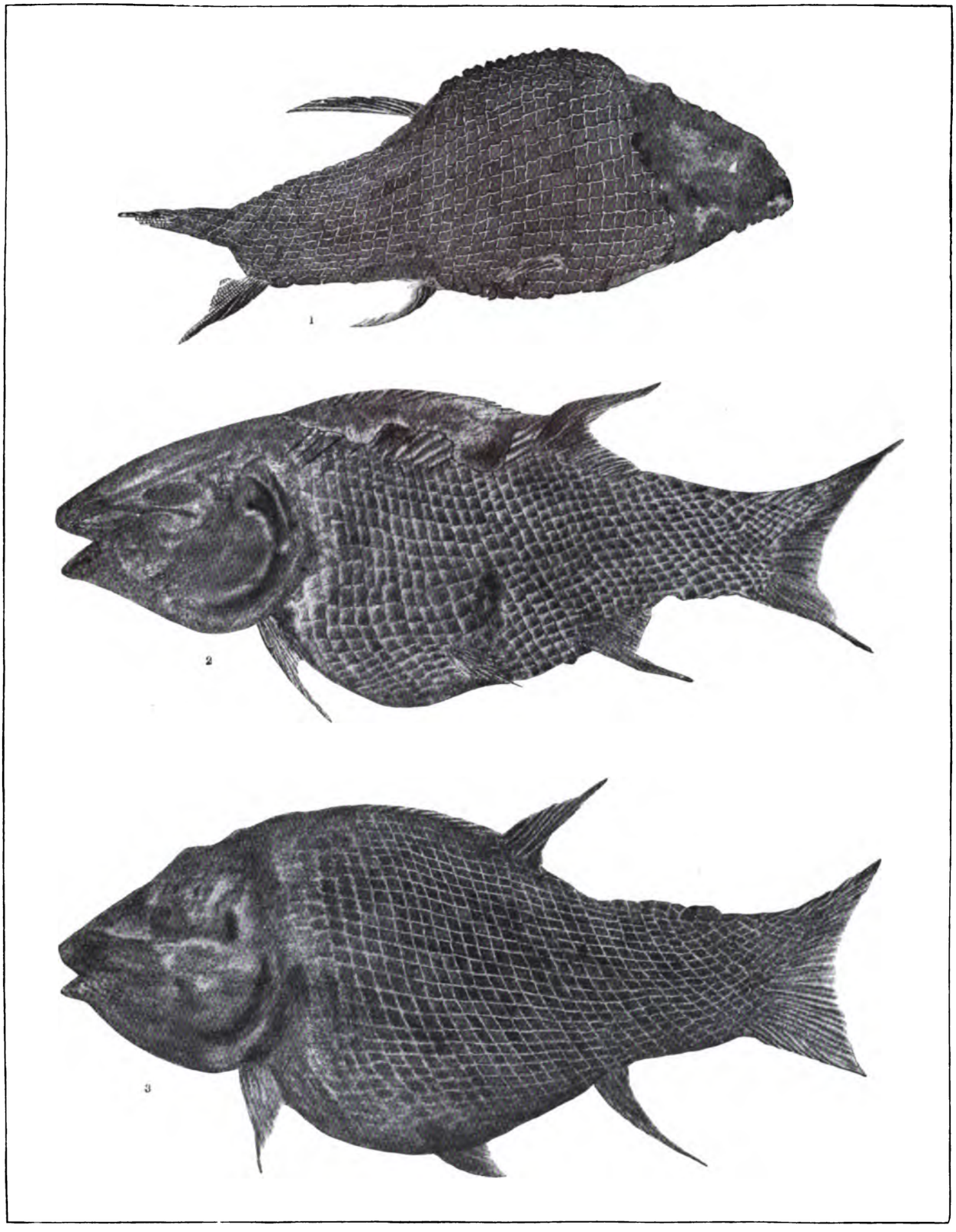
2, 3.	ISCHYPTERUS LENTICULARIS Newb., Boonton, N. J	39



1. ISCHYPTERUS ELEGANS.

2, 3. ISCHYPTERUS LENTICULARIS.

PLATE XI.

PLATE XI.

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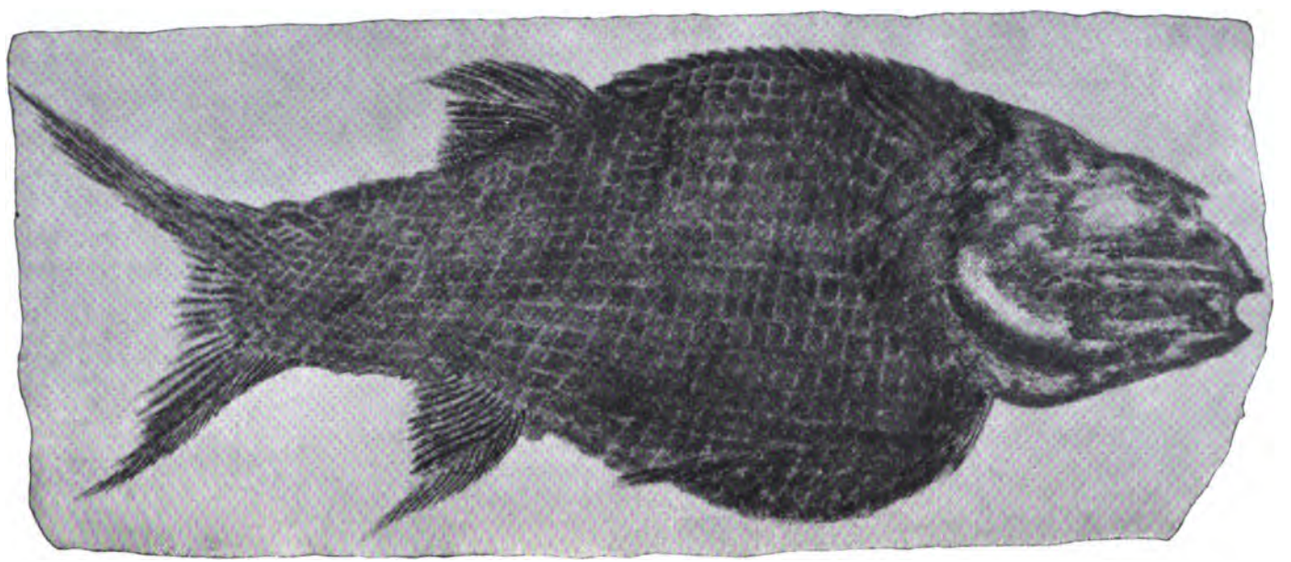
FIG. 1. ISCHYPTERUS LINEATUS Newb., Boonton, N. J 40

2. ISCHYPTERUS LINEATUS 40

2



1

ISCHYPTERUS LINEATUS.

PLATE XII.

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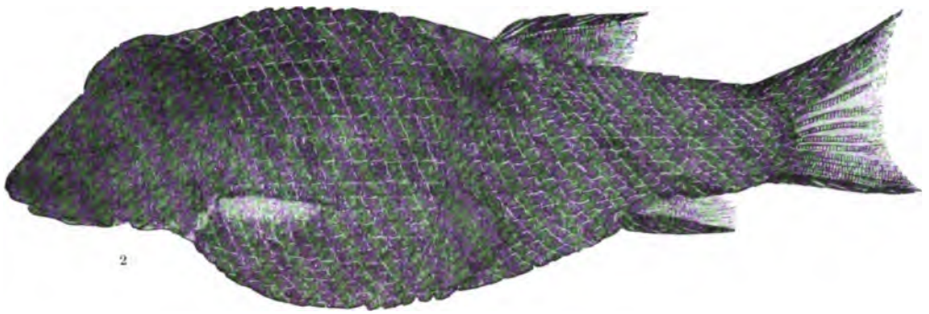
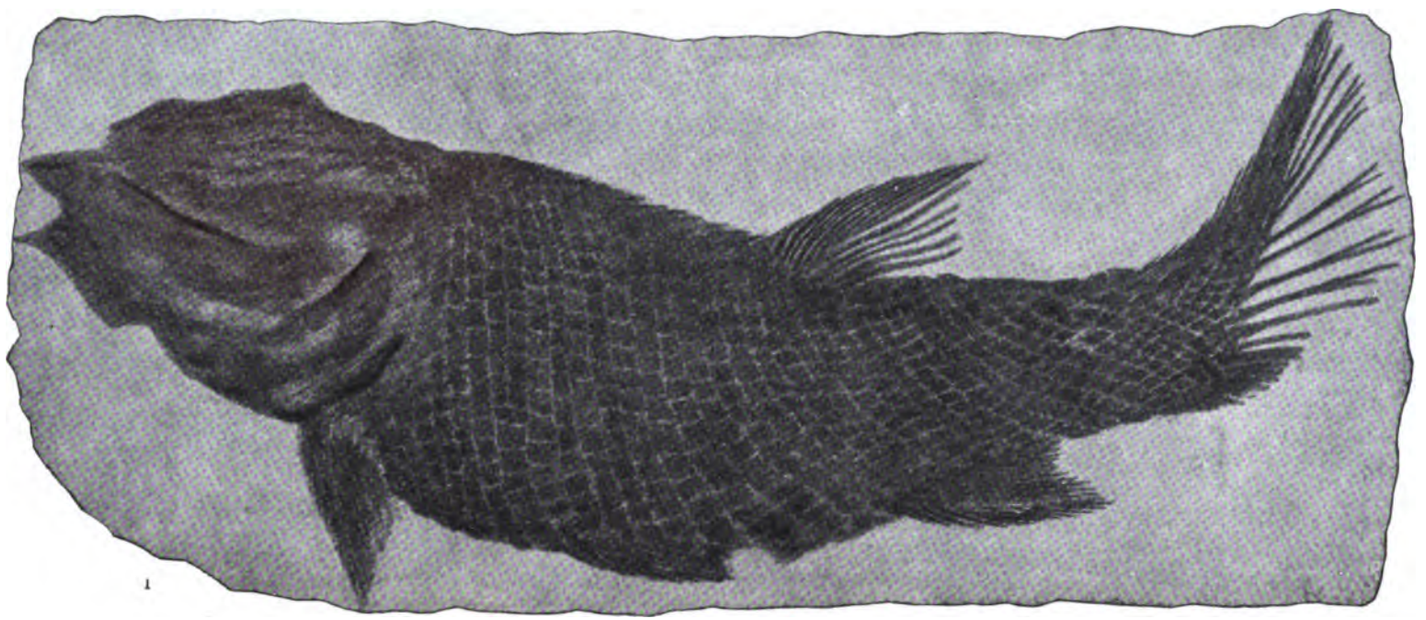
2. ISCHYPTERUS MICROPTERUS Newb., Durham, Conn. Young individual	31
3. ISCHYPTERUS BRAUNII Newb., Weehawken, N. J. Young	43





1. ISCHYPTERUS MACROPTERUS. 2. ISCHYPTERUS MICROPTERUS. 3. ISCHYPTERUS BRAUNII.

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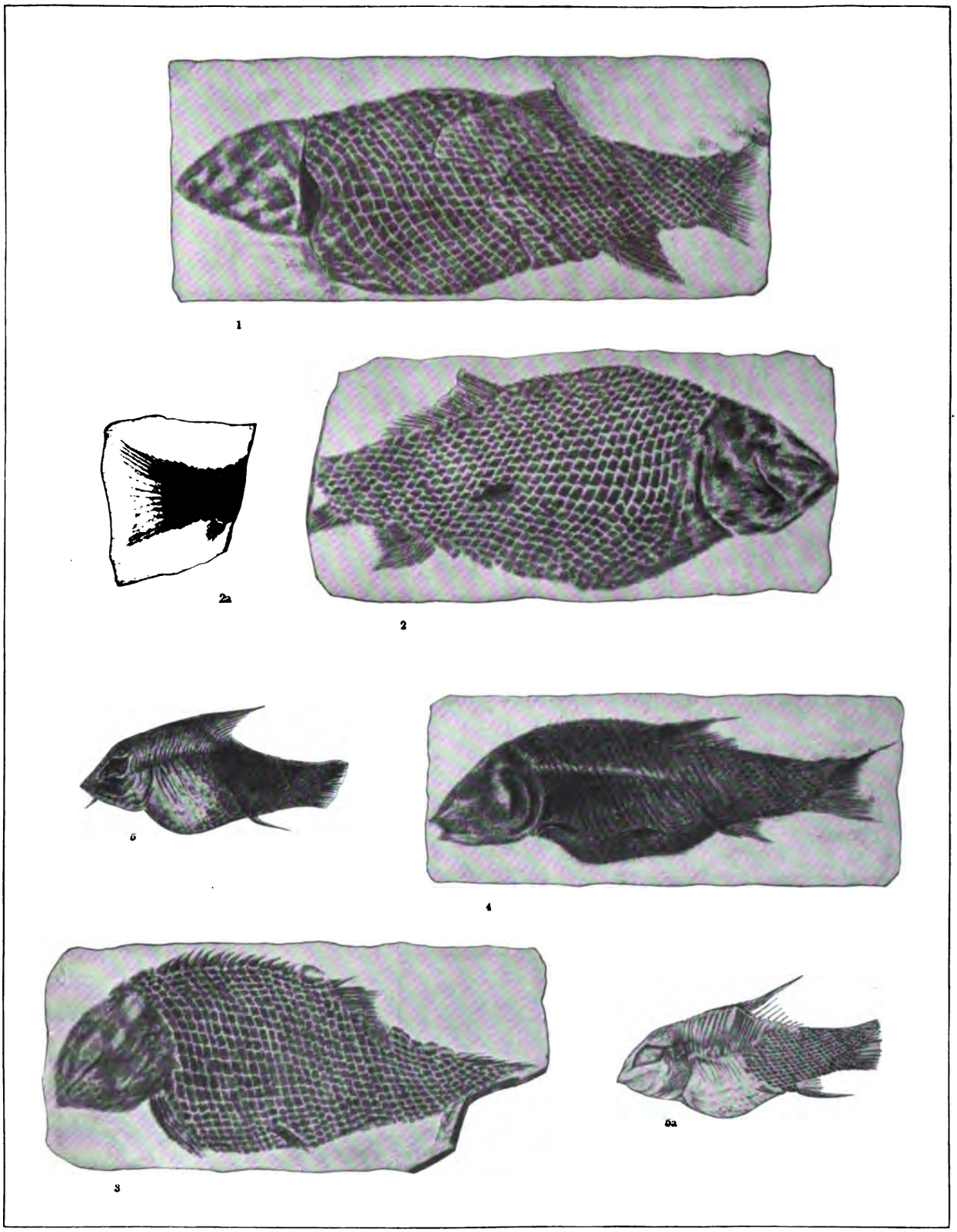
5, 5*a*.	ISCHYPTERUS MINUTUS Newb., Durham, Conn	48



1, 2. ISCHYPTERUS BRAUNII. 3. ISCHYPTERUS LATUS. 4. ISCHYPTERUS PARVUS. 5. ISCHYPTERUS MINUTUS.

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PLATE XIV.

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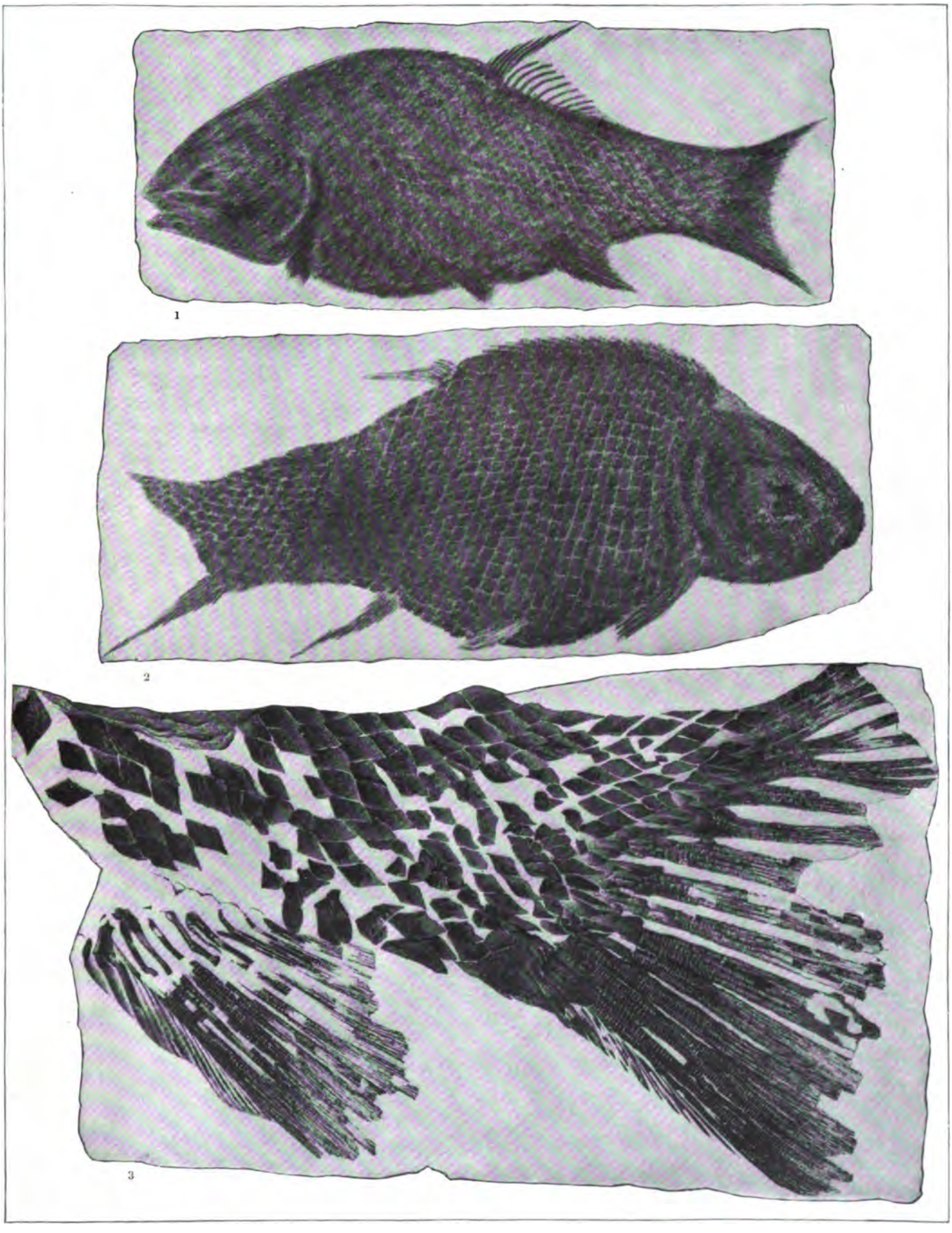
3. ISCHYPTERUS GIGAS Newb., Boonton, N. J. Tail of a fish nearly two feet in length	49



1, 2. ISCHYPTERUS ELEGANS.

3. ISCHYPTERUS GIGAS.

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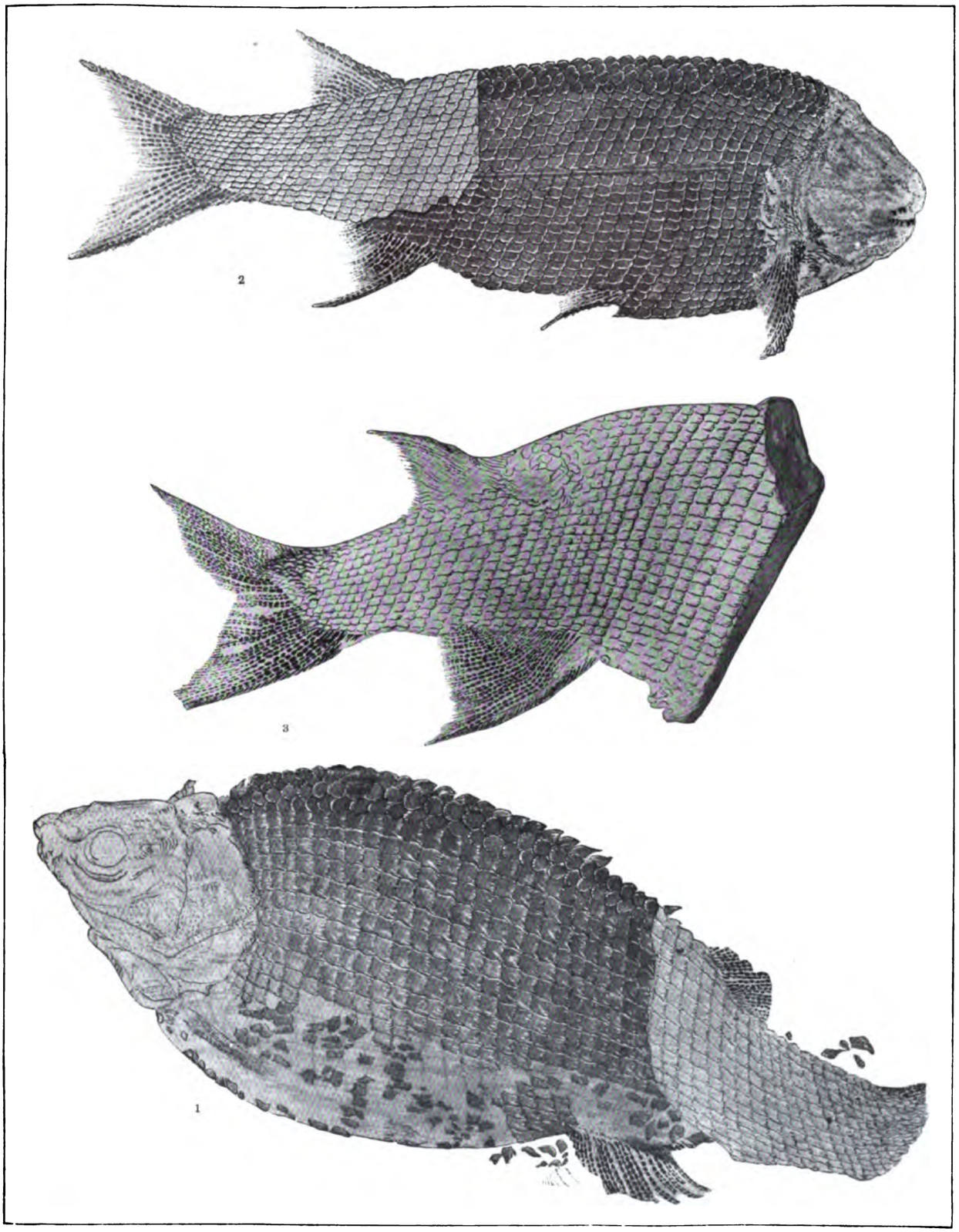

CATOPTERUS REDFIELDI.

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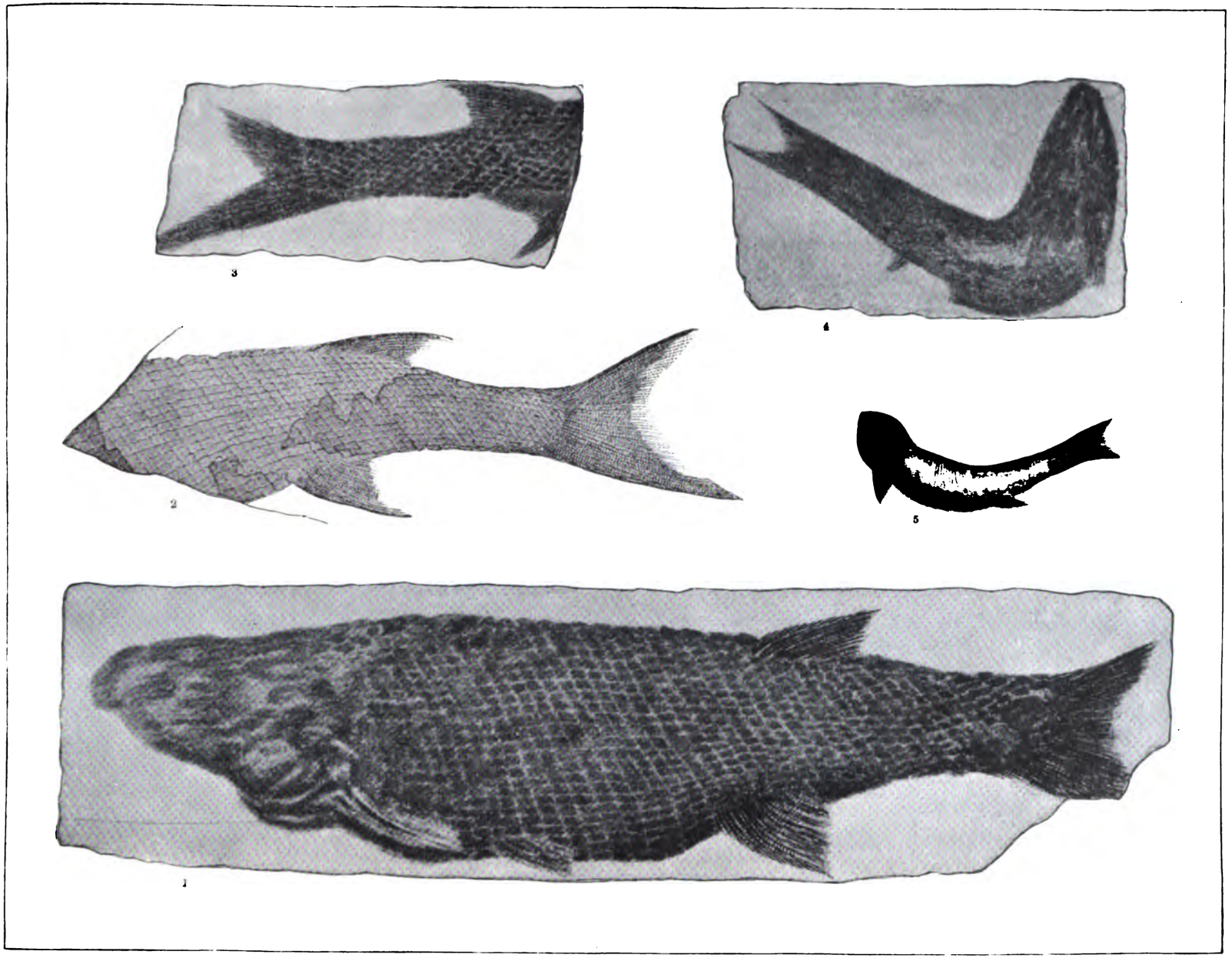
PLATE XVI.



1, 2, 3. CATOPTERUS GRACILIS.

4, 5. CATOPTERUS PARVULUS.

PLATE XVII.

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FIGS. 1, 2, 3, 4, CATOPTERUS MINOR Newb., Durham, Conn 57

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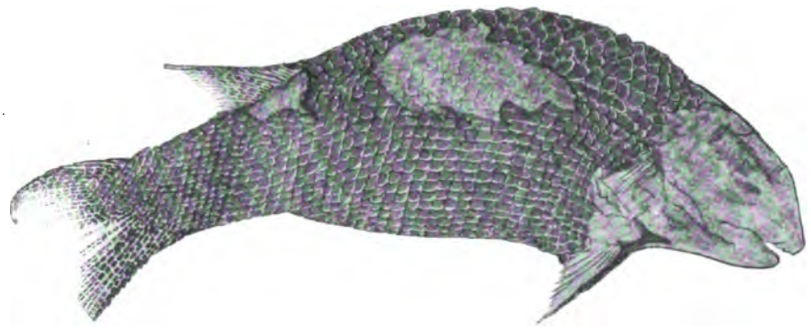
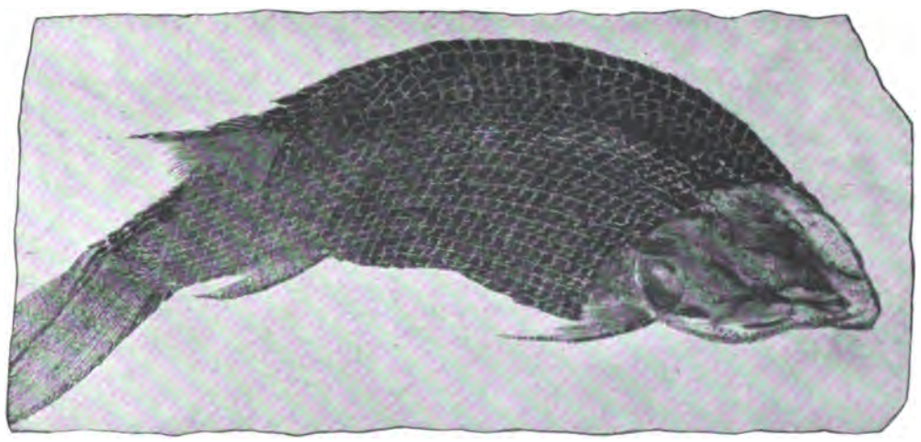


3



4

CATOPTERUS MINOR.

PLATE XVIII.

PLATE XVIII.

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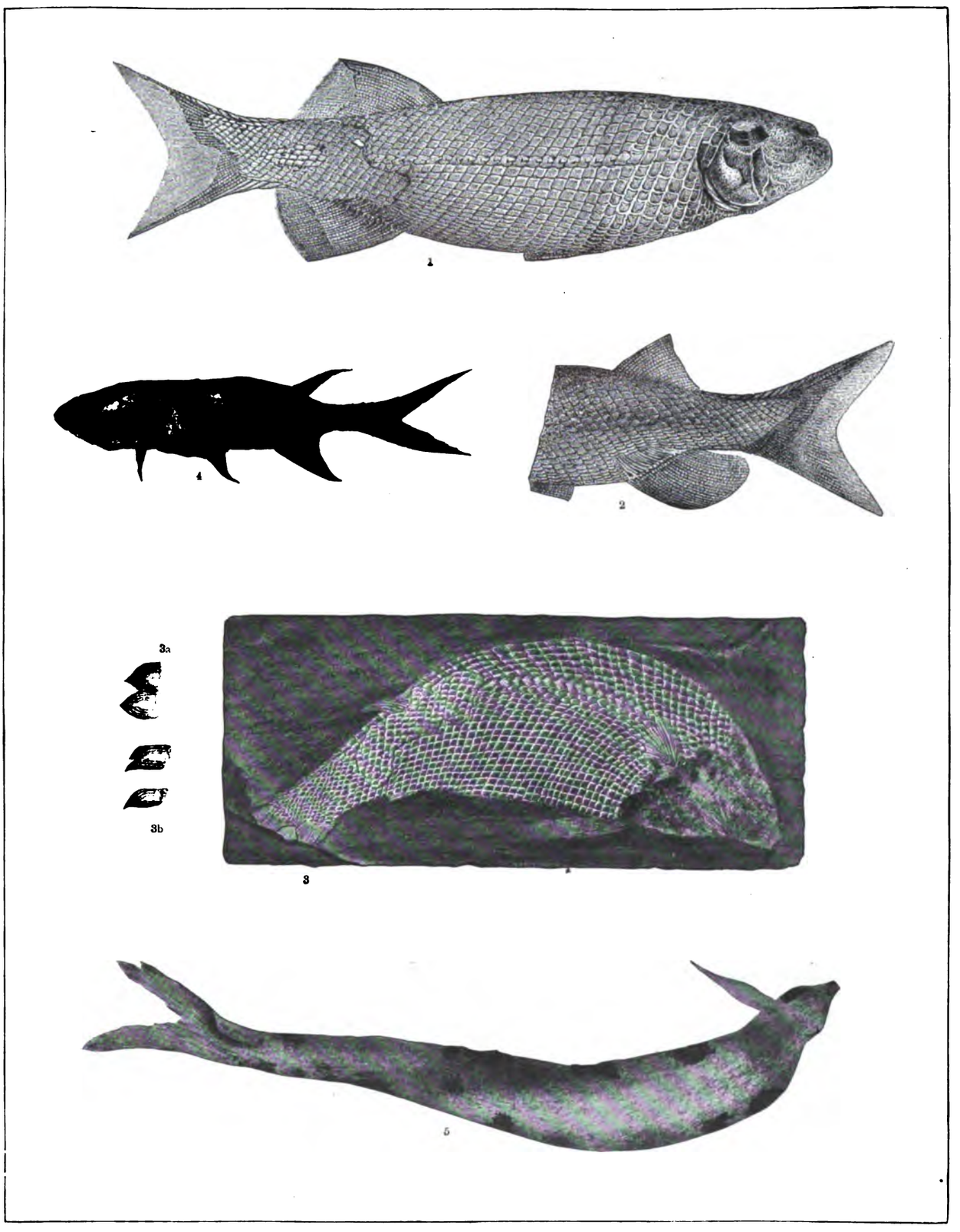
5. CATOPTERUS ANGUILLIFORMIS W. C. R., Durham, Conn	59



1, 2. DICTYOPYGE MACRURA. 3. CATOPTERUS ORNATUS. 4. CATOPTERUS. 5. CATOPTERUS ANGUILLIFORMIS.

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PLATE XXII.

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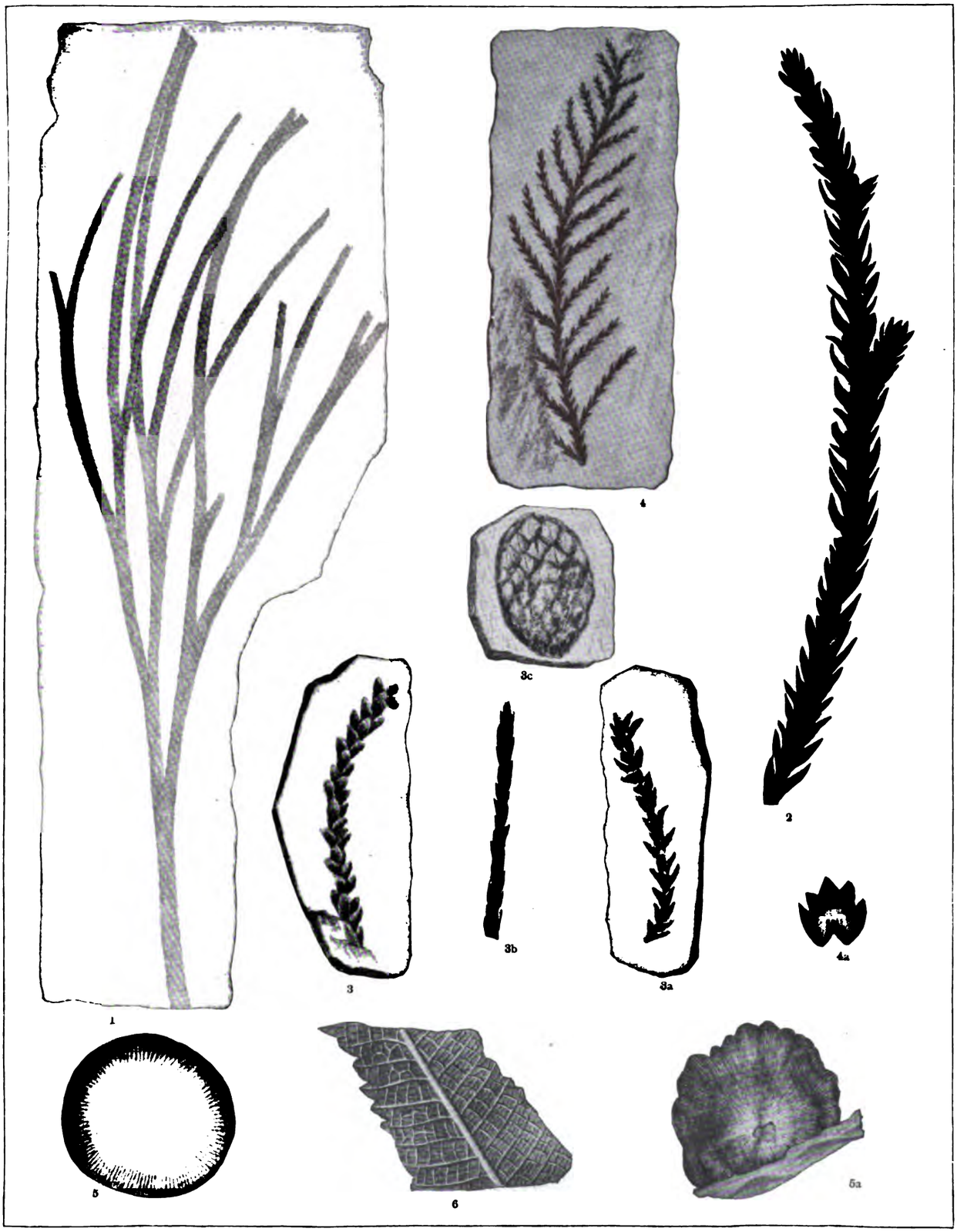

1. BAIERA MÜNSTERIANA.
2. PACHYPHYLLUM SIMILE.
3. PACHYPHYLLUM BREVIFOLIUM.
4. CHEIROLEPIS MÜNSTERI.
5. PHRAGMA OF EQUISETUM ROGERSI.
6. CLATHROPTERIS PLATYPHYLLA.

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PLATE XXIII.

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BAIERA MULTIFIDA.

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PLATE XXIV.

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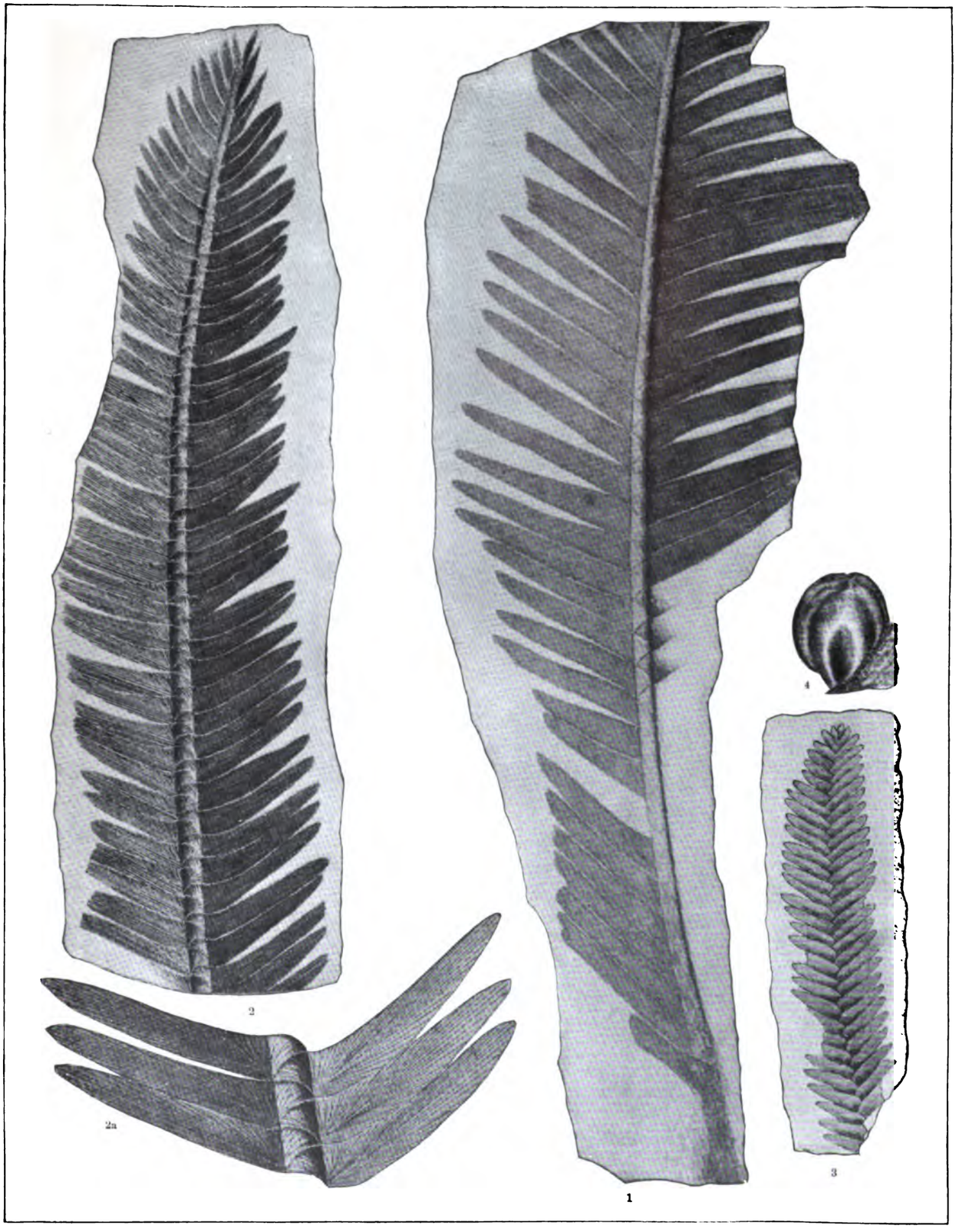

1, 2. OTOZAMITES LATIOR. 3. OTOZAMITES BREVIFOLIUS. 4. CYCADINOCARPUS CHAPINI.

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PLATE XXV.

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1, 2, 3. LOPERIA SIMPLEX.

4. DIOÖNITES LONGIFOLIUS.

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PLATE XXVI.

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Figs. 1, 2. Trunk of conifer (*Palissya*?) decorticated, showing rhomboidal markings on surface, Newark, N. J..... 94

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TRUNK OF CONIFER (PALISSYA?).

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